NOVEMBER • 1955

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

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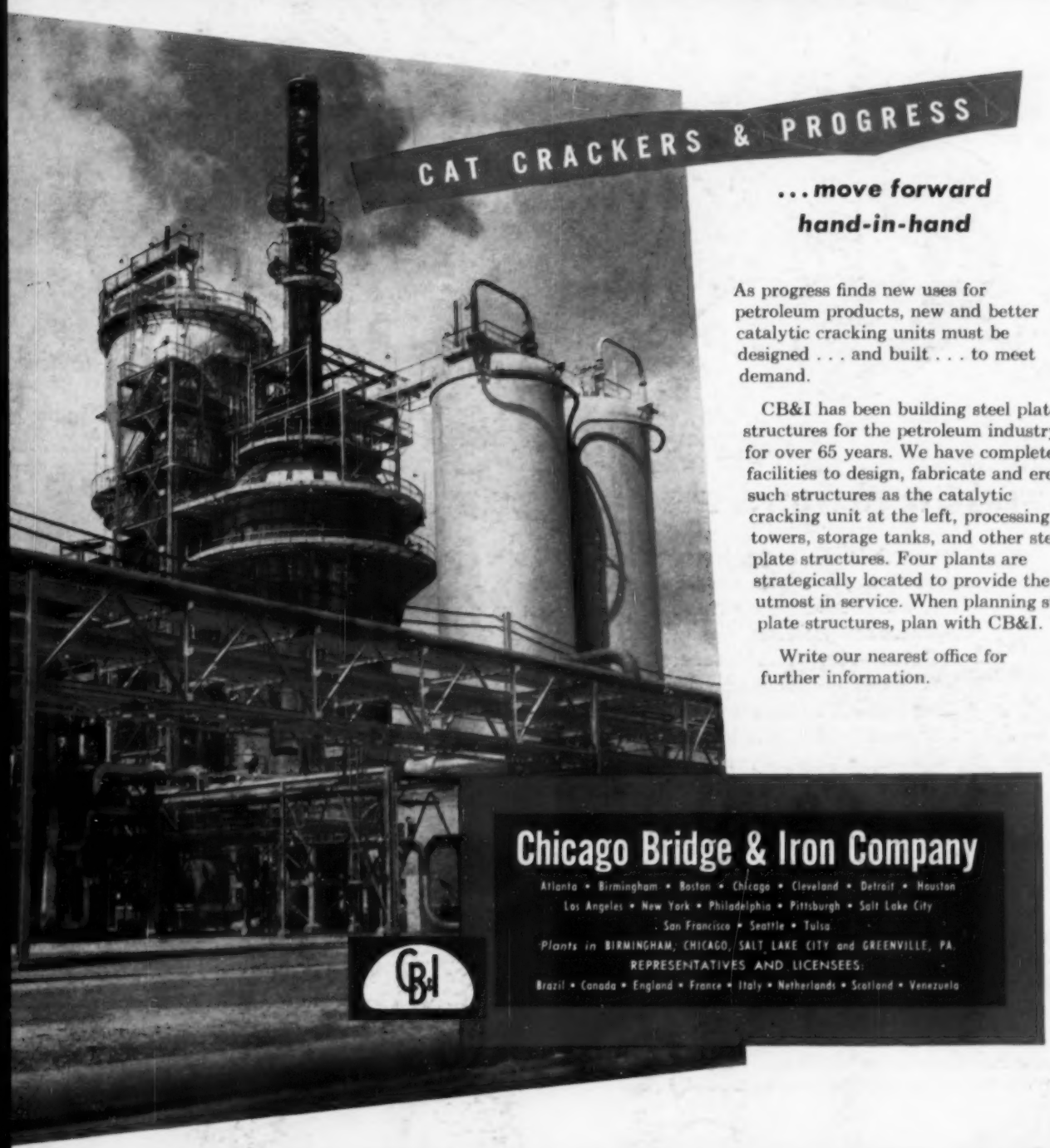
FIRED HEATER Symposium Page 140

New Analytical Tool..... Page 165

Save Money With 'O' Rings.. Page 201



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REFINER
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A Quick Look
at This Issue

These handy digests permit checking ✓ those articles you want to read first.

FIRED HEATER SYMPOSIUM

☐ **Flashflow Pressure Drop in Heaters . . .** Here are fast and simple ways to find the pressure drop in heater tubes with evaporating fluid. Improve your understanding of the subject while you learn the shortcuts. **Page 140.**

☐ **Hydrogen Fuel Makes Problems . . .** You can get a better understanding of hydrogen as it behaves in burners and in the fired heater combustion chamber. Here is a look at some of the trouble found in reformer heaters using hydrogen fuel. **Page 153.**

☐ **It Pays to Select Cat Reformer Heaters With Care . . .** Up-to-the-minute information on cat reformer heaters and some do's and don't's. Reformers are here to stay. Keep posted and avoid trouble. **Page 155.**

☐ **How to Get Basic Heater Specs . . .** Here are some pointers that will give you the ABC's of writing direct fired heater specifications. Refresh your knowledge with this discussion. Turn to **Page 159.**

☐ **How to Use Resid as Furnace Fuel . . .** Increasing fuel costs are pointing the way to changes in furnace fuels. Here is the background on the problems, the potential advantages and actual application experiences. **Page 161.**

☐ **New Tool: Vapor-Phase Chromatography . . .** A powerful analytical technique for simple and rapid analysis of gases and liquids boiling up to 300 C. The separating principle is selective sorbtion. This article gives a complete picture of the subject which the authors developed from many sources. **Page 165.**

☐ **How to Classify Hazard Areas . . .** Here is the full background on the new API RP-500 for area classification in electrical installation. A must for those interested in design, maintenance or operations. **Page 166.**

☐ **Heat Exchanger Design (Part 3)—Fluid Flow and Thermal Design . . .** The third article in this series covers fluid flow and presents an

→ Now Turn the Page →

A Quick Look at This Issue

example of the thermal design of an exchanger. Charts are presented for the rapid solution of shell side and tube side pressure drops. **Page 175.**

☐ **Comparing Olefin Unit Feedstocks . . .** Economics calculated indicate that butane may soon be competitive with propane as feed for ethylene and propylene units. Although butanes are relatively expensive raw materials, they possess unique advantages. Where a market for propylene exists, butane appears competitive under the present price structure. **Page 185.**

☐ **How to Eliminate H_2S Odors . . .** No refiner need to be sold on the desirability of eliminating the source of such an obnoxious and toxic gas H_2S from an operating unit area. Engineers at this refinery have worked out a cheap but satisfactory solution at a cat cracker unit by using flue gas to strip H_2S from foul water before it reaches the sewer. **Page 191.**

☐ **Carefull Mists Can Explode . . .** It's true, too. You may have felt that so long as the mist of combustible liquids is well below the flash point that you could not have an explosion. Well, the facts are told in this article and . . . mists of flammable liquids can be fully as dangerous as vapor-air mixtures. Surprised? See for yourself on **Page 194.**

☐ **Handling Reduced Crudes . . .** Here is the way over-all refinery product distribution was changed to increase light product yields by 2 percent with a like reduction in fuel oil production. The story is complete with process data and typical operating conditions. **Page 197.**

☐ **Save Money with "O" Rings . . .** An "O" ring flange requires less initial bolt tension to make a connection; therefore, less stress is carried over into the piping system. The authors conclude that a 300 ASA flange with an "O" ring can give cold-service pressure ratings equal to the 600 ASA ring joint for sizes up to 12 inches. **Page 201.**

☐ **Nomograms . . . Make Your Own (Part 2)** . . . This second part of a most helpful series tells you how to lay out the various types of nomograms. The scales are shown and explained. This is step 2 in teaching yourself how to make these valuable aids. **Page 205.**

☐ **Gas Conditioning Today (Part 1) . . .** It's time to take a look at what's happening in this field—what the problems are and how they're being solved. There has been a lot written but you'll find no better summation than what these experts have to say about the field today. The first part of this series will bring you up-to-date on particulate matter removal and gas purification. **Page 209.**

☐ **How the Esso Fluid Hydroformer Performs . . .** A complete description of the Baton Rouge plant and the process used. Included are data on feed and yield, both quantity and quality. Keep your fund of reforming knowledge current by reading this complete discussion. **Page 214.**

☐ **New Method for Pipe Stresses (Part 2) . . .** You'll find this method a big time-saver in computing stresses in a three-dimensional piping system, as well as making the whole procedure much simpler. Compared to tedious conventional methods, this one will help you avoid common errors. The second part in this series shows you how to use the tabular method when the system contains branches with different moments of inertia. **Page 217.**

☐ **Hydrogenating Wyoming Black Oils . . .** Some of these crude have peculiar characteristics when refined using normal processing techniques. Pilot plant tests, however, indicate that considerable improvement may be effected by high-pressure hydrogenation. For more details, see **Page 219.**

☐ **A Practical Application of Combination Processing . . .** This is a valuable tool in the petroleum industry. It can be applied in various processing fields. Application of the combination processing technique results in considerable investment savings while operating costs may be minimized because of a reduction in manpower and because of utilizing optimum heat economy. You'll be interested in how this fluid combination unit is operated in Antwerp. **Page 221.**

☐ **Texaco Doubles Refinery Investment . . .** In a decade of following the trend toward fewer but larger refineries, The Texas Company has seen its crude capacity increased 55 percent and its high-octane facilities expanded more than fivefold. Texaco's expansion story is the second in a series on postwar refinery construction. **Page 138.**

☐ **Are You Hiding Employe Talent? . . .** If you need engineers, chemists or technicians, look first in your own back yard. You might find an employe with these qualifications working at some unimportant job. **Page 246.**

☐ **Two-Way Radio Helps to Confine Disaster.** What would you do if a blast rocked your refinery? Would your communications system be ready for all emergencies? For a colorful description of the part two-way radio played in curbing Standard of Indiana's Whiting fire, turn to **Page 250.**

☐ **Skin Disease Called a Hazard to Refinery Workers . . .** Diseases of the skin are said to be taking a far larger toll of the nation's industrial output than all other occupational diseases combined. In the refining industry alone, 473 workers out of 14,000 were found to have dermatoses. For a common-sense solution to the problem, turn to **Page 252.**

For a Quick Look at INDUSTRY This Month, turn now to Page 129

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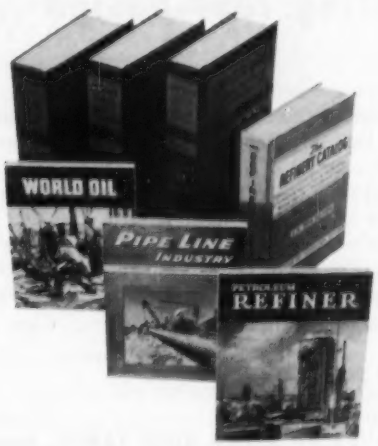

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PETROLEUM REFINER and The REFINERY CATALOG for the refining-natural gasoline-petrochemical industry

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Improving the Best

YOU HAVE ALL heard about the little boy who grew up and made an outstanding man—well that is happening to petrochemicals in a big way. They aren't completely grown yet but let us say they are in the young man stage and getting ready to "bust out over all."

To keep our readers abreast of the times in this dynamic industry we have picked some 80 manufacturing processes and 10 separation processes of the most interesting petrochemicals for presentation in our December *Petrochemical Handbook* issue. Leading off the issue will be an unusual array of topnotch articles about the industry in general with considerable thought being given to its future.

This second issue of the *Handbook* will be even better than the first issue, which, in 1953 won for the PETROLEUM REFINER an award in *Industrial Marketing's* competition for the most outstanding single issue of all industrial papers during 1953.

PR Campaigning Too

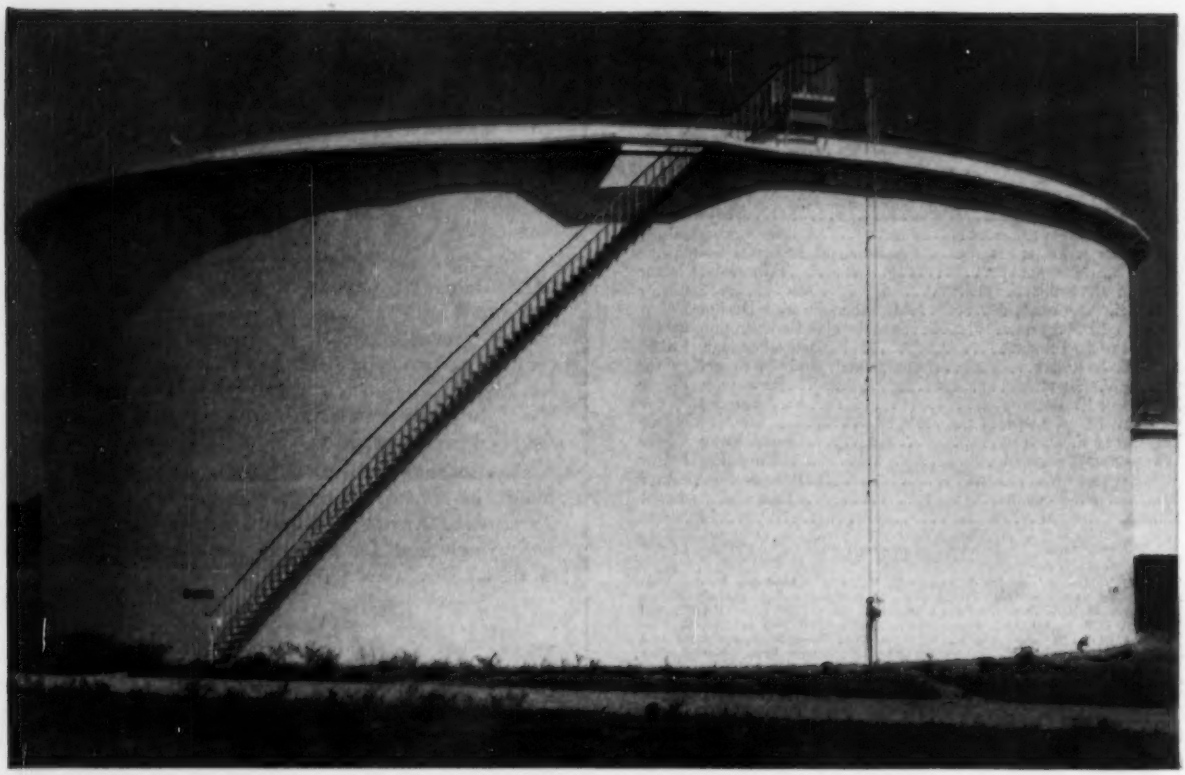
Someone is always trying to convince engineers that they can write better technical reports. Or, maybe we can just leave off the last two words and say simply *write better*. Certainly there is room for improvement. You don't have to read many technical "papers" to become convinced of that. So wherever and whatever efforts are made to get today's engineers out of yesterday's practices are worthwhile and deserve high commendation.

Three years ago we issued a little booklet dealing with how PETROLEUM REFINER articles are selected and should be prepared. It wasn't our first punch at the target but perhaps it was our most effective up to that time. Some 20,000 copies were distributed.

We think it a good idea with good results. So we've gone over the booklet very carefully, made numerous revisions and a second printing soon will be ready for distribution. If you are interested as a writer or a potential writer in the type of articles presented each month by PR please ask for a copy. Just address Editorial Director, PETROLEUM REFINER, Box 2608, Houston 1, Texas.

Canada Votes "Aye"

Last month on this page we quoted a PETROLEUM REFINER reader who resides in El Paso, Texas. This month, to show you that we get around and that no matter where we go we run into words of wisdom, let's switch to Toronto, Ontario, Canada. Although the locations are far apart, the theme of the two comments are about the same. Last month the brother in El Paso wrote "of most interest to us (in PR's pages) are the advertisements." This month, Canada, after praising the "admirable balance achieved in your excellent magazine," chimed in with "P.S. Even the advertisements are good."



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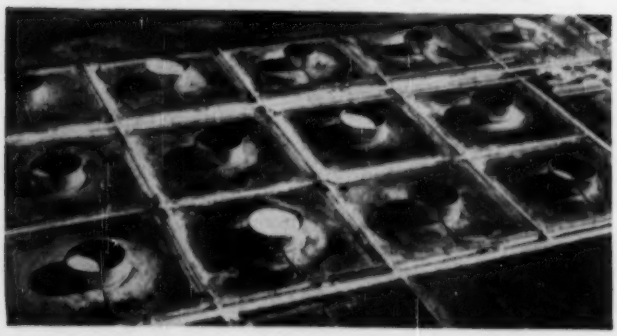
GRAVER *...a conservation design to fit every need*



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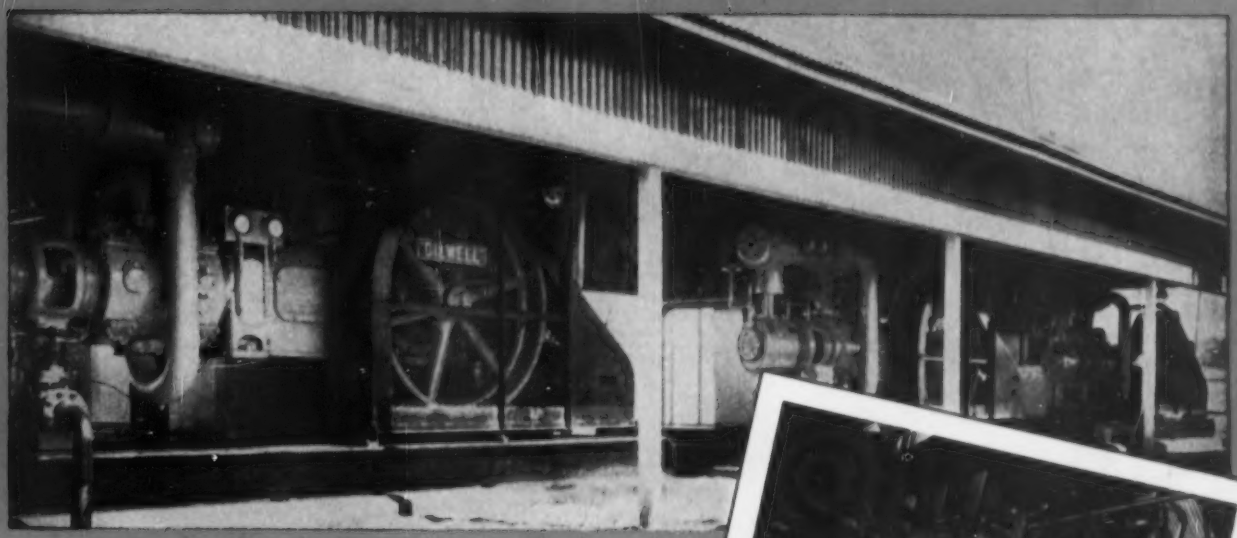
Three "Oilwell" Compressor Units ...handle the gas from start to finish



...in this skid-mounted Portable Gasoline Plant

WHEN TURNER & WEST of Graham, Texas purchased this portable gasoline plant which is located near Loving, Texas, "Oilwell" Compressor Units were selected because of the consistently good performance and low-cost maintenance records that previously purchased "Oilwell" units had established for this customer.

Wet gas from the separator enters the compressors at atmospheric pressure and is boosted to 150-200 psi as required for processing through the plant.

A total of 275 hp is required to drive the three packaged compressors. Two GBU-75 two-stage units each have a maximum capacity of 500,000 cubic feet of gas per 24 hours of operation and one GBU-125 two-stage unit has 750,000 cfd capacity.

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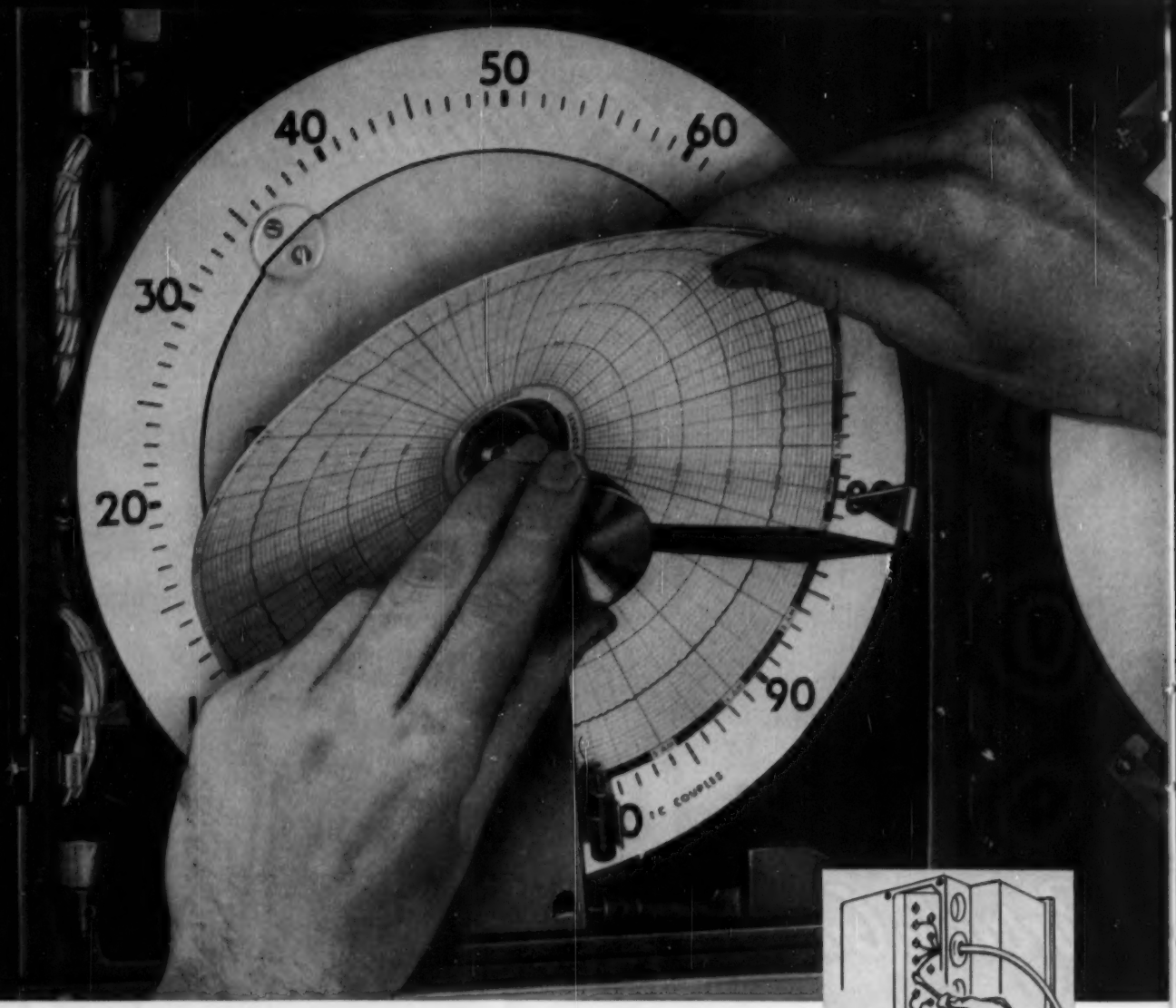
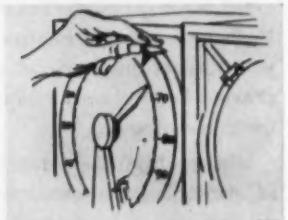


To put in operation, simply connect leads to back of case . . .



. . . set control point setter
. . . turn on power switch.

A new concept in . . .

operating ease

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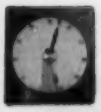

Although this round chart Speedomax H is small in size, you can set the control point or read it from a distance almost as easily as "big" instruments. For the easy-to-see control and indicating pointers travel around a large 23-inch scale. Chart changes take less than a minute!

All wiring connections are made to an external terminal board, at rear of the case. If you move the instrument from job to job, range changes can be made on the spot. A screw driver is the only tool you need.

Whether you're using a simple indicator or a 3-action controller, all components are in one compact unit. Relays, amplifiers, etc., have plug-in connections.

In short here's a complete line of null-balance potentiometers available for a broad-range of temperature measurements including many now being made with non-potentiometer instruments.

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"CHROMACON" APPARATUS for Vapor Phase Chromatography

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VAPOR PHASE CHROMATOGRAPHY

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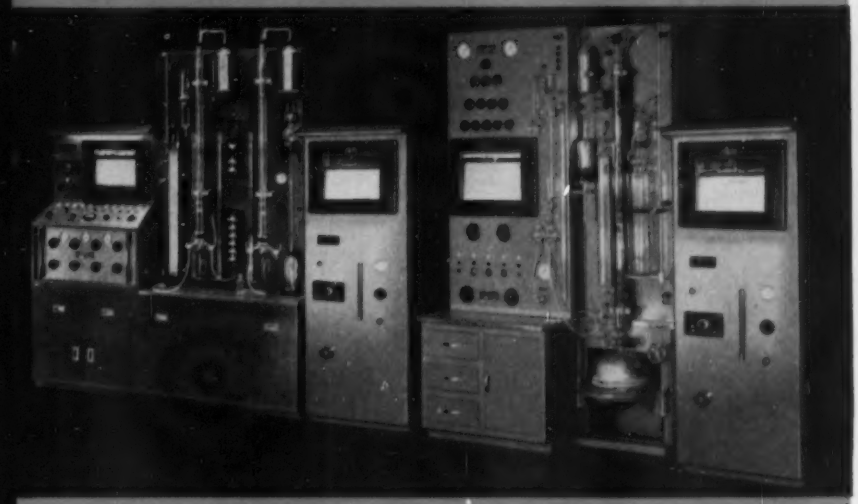

THERMOCON
Automatic Recording Low-Temperature Analytical Distillation Apparatus with Coupled CHROMACON.

HYPER-CAL
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Other combination models available.

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Vapor Phase Chromatograph Apparatus
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The CHROMACON is designed according to the latest advances in this analytical technique, and with the benefit of 25 years of experience by Podbielniak in the field of distillation, adsorbent and solvent separations.

The CHROMACON comprises: three stainless steel chromatographic columns, with compression metal couplings, a special, high-sensitivity, low-holdup thermistor type thermal conductivity cell detector and circuits; a fluid-damped precision pressure regulator and needle valve to control flow of carrier gas; sampling section; an electrically heated thermostatted enclosure (to 160°C.) around the columns and detector cell; all necessary connections, gages, controls, etc. The special electronic recorder, as illustrated, has 1 sec. full scale pen travel, 1 mv. range, rapid chart travel.

Write for Prices and Detailed Information.

APPLICATIONS

For Primary Analysis: The CHROMACON, whether separate or combined, may be used for the rapid analysis of a great many mixtures, within the scope and limitations of the vapor phase chromatography method. Write for detailed information.

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What one tube steel will give you the best life/cost ratio? *Ask the experts!*

This month's report is on: **DM STEEL**

Has unusually high creep strength for a pearlitic steel, good stability up to 1200°F., fairly good corrosion and oxidation resistance. Has 2 to 3 times the life of carbon steel where corrosion is not severe. Recommended for cracking furnace tubes, hot oil lines, superheater tubes, high temperature steam piping and forgings for accessory parts.

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Silmo	Sicromo 3	Sicromo 9M	25-12*
DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	16-25-6**

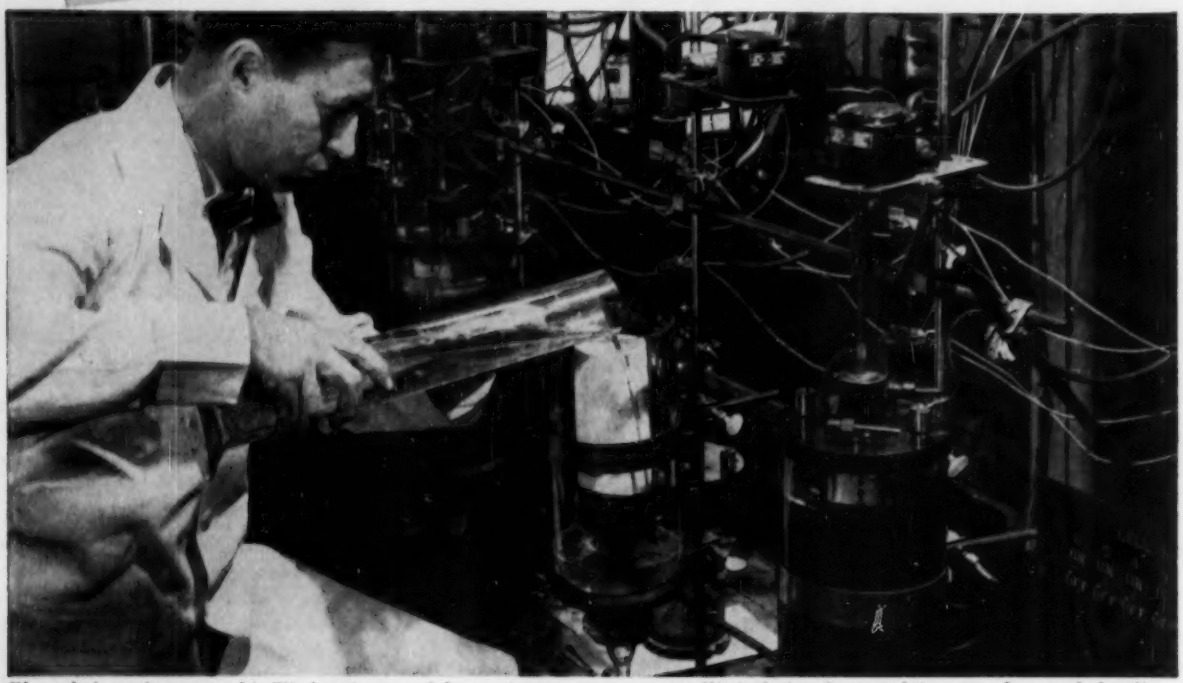
*Available as seamless tubing on an experimental basis only.
**Not available as seamless tubing.

THERE are probably several high temperature tube steels that will solve your heat, pressure, corrosion and oxidation problems. But there's only one analysis that will give you maximum tube life per dollar.

To find it, *ask the experts!*

With over 20 years of steel research and experience, Timken Company metallurgists are recognized authorities on high temperature steels. They'll use this experience to help you select from 24 different analyses, pick the one tube steel that will give you the best life/cost ratio. And regardless which analysis you select, you'll be assured of uniform quality because the Timken Company rigidly controls quality from melt shop through final inspection.

Let the Timken Company's RSQ—Research, Supply, Quality—solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".



Electrolytic equipment used in Timken Company laboratories to extract non-metallic inclusions from steels in research on steel cleanliness

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

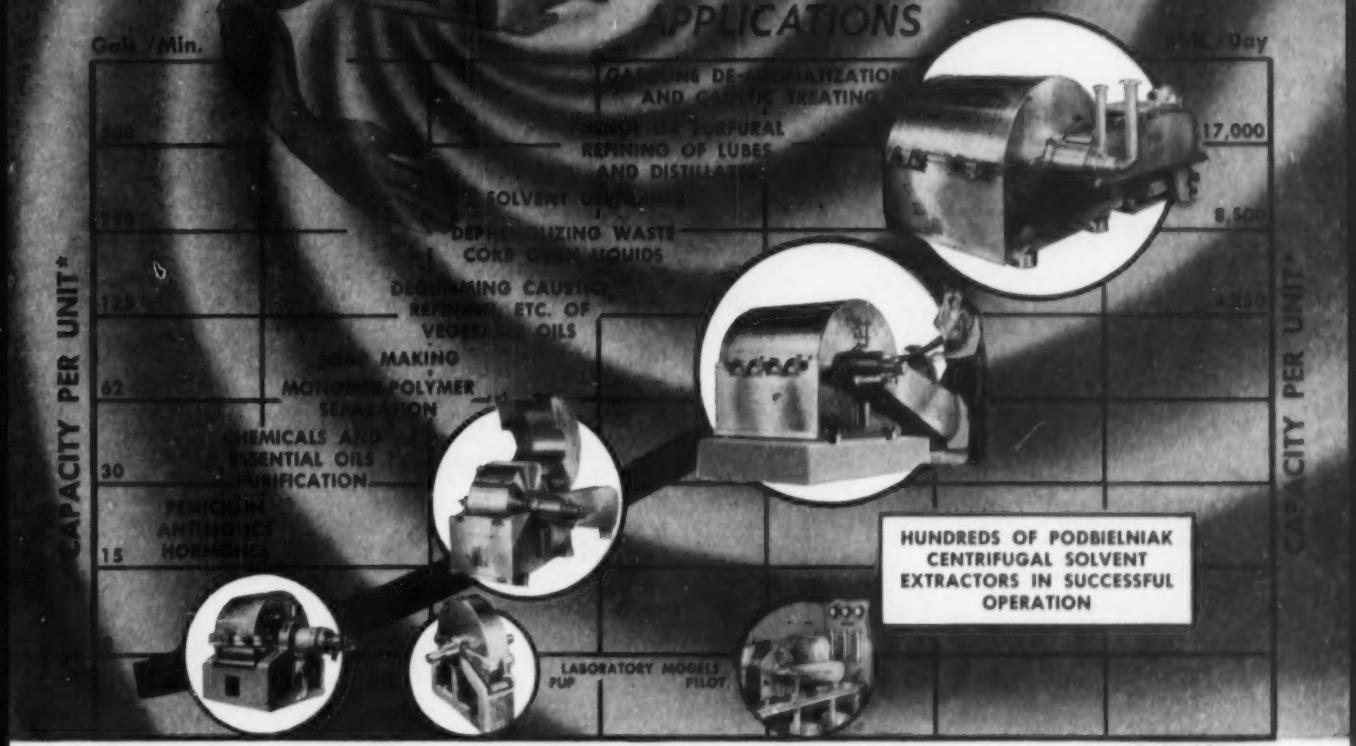
SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

GROWN INTO A WHIRLING GIANT!!

Podbielniak CENTRIFUGAL MULTI-STAGE SOLVENT EXTRACTOR

- PROVEN
- ECONOMICAL
- UNIQUE ADVANTAGES OVER ALL OTHER EQUIPMENT

LET US HANDLE YOUR PROBLEMS



HUNDREDS OF PODBIELNIAK CENTRIFUGAL SOLVENT EXTRACTORS IN SUCCESSFUL OPERATION

*Combined Streams

NEWEST DEVELOPMENTS

Capacities to 500 gallons per minute in single units; available mid-feeds for water or reflux injection, etc.; automatic flow and interface control, V-belt or chain drive; two-speed special motor or Gyrol drive; proven designs for processing all types of liquid-liquid contacting materials and processes, particularly the "tough" ones.

DISTINCTIVE FEATURES

Centrifugal Settling and Clarification, as well as centrifugal contacting; a great advantage in handling troublesome emulsifying or small-density difference materials.

Negligible Holdup of Materials and Short Time of Contact: No investment in thousands of gallons of valuable solvent or materials; minutes only are required to start extractor or to change feeds or operating conditions, and reach full operating equilibrium.

Simple Construction, Installation and Maintenance. The centrifugal extractor is extremely simple to install; easy to operate because of compactness, and prompt reaction to controls; reliability in service and low maintenance costs are proven by hundreds of successful installations.

Our engineers will gladly correspond regarding application of our extractors to specific processes.

PODBIELNIAK, INC. 341 E. OHIO STREET, CHICAGO 11, ILLINOIS

Here's money-saving news

from the laboratory of a major West Coast refinery*

Di-tertiary-butyl-para-cresol is the most economical, most effective antioxidant for use in both regular and premium gasolines.

That's the conclusion reached by the research department of a West Coast refinery after several years of exhaustive tests on various types of gasoline inhibitors.

This outstanding additive actually prevents the formation of gum in gasoline, resulting in a *cleaner* gasoline and a *cleaner* engine.

In addition, production costs can be considerably reduced by diverting distillates to less expensive and less severe finishing operations, since di-tertiary-butyl-para-cresol can be added early in the process to gasoline streams *before* the unstable components come in contact with air. This insures the maximum protection at least cost.

Further protection is assured in the automotive engine because it effectively retards deposit formation.

Koppers is a major manufacturer of di-tertiary-butyl-para-cresol, which is sold under the trade names of **dbpc**®, and Impruvol 33®. For further information, write to:

**Name supplied on request*

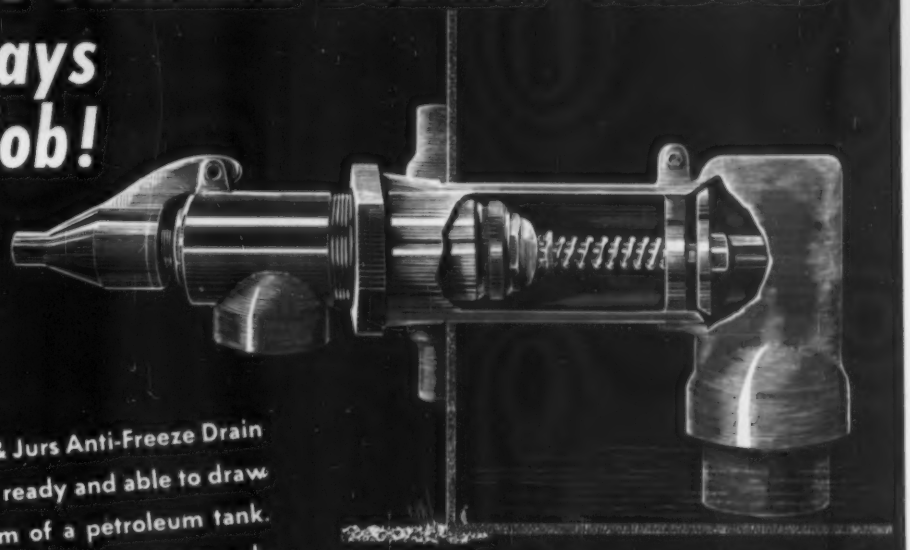
KOPPERS COMPANY, INC.
Chemical Division, Dept. PR-115, Pittsburgh 19, Pennsylvania

KOPPERS ® **Koppers Chemicals**

SALES OFFICES: NEW YORK • BOSTON • PHILADELPHIA • ATLANTA • CHICAGO • DETROIT • HOUSTON • LOS ANGELES

S&J ANTI-FREEZE DRAIN VALVES

Always on the Job!

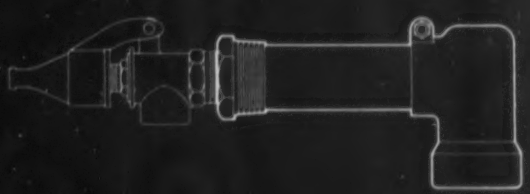


Here's the Shand & Jurs Anti-Freeze Drain Valve that is always ready and able to draw water off the bottom of a petroleum tank. It will remain operable even during sub-freezing weather conditions. It's self draining; water will not remain inside the valve body. Obviously the valve cannot freeze up and become inoperable.

The unique design of the S&J Anti-Freeze Drain Valve, designated as Fig. ST-2001, calls for mounting in strong threaded flange or coupling welded into the tank shell so that threads do not warp. This prevents loss of product and incidental hazards, and facilitates removal of the drain valve for cleaning or maintenance.

Above: Fig. ST-2001 AV Anti-Freeze Drain Valve with auxiliary valve which permits removal of the Drain Valve from a tank without draining tank contents.

Fig. ST-2001 Anti-Freeze Drain Valve with adapter for Cone roof tanks.



The S&J Anti-Freeze Dain Valve, Fig. ST-2001 is available in 2", 3" and 4" sizes.

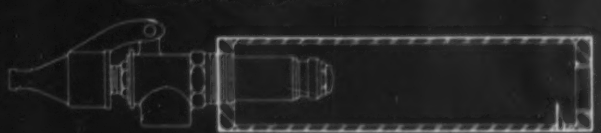


Fig. ST-2001 S Anti-Freeze Drain Valve with eccentric sleeve is designed for use in Spheroids and other tanks with curved bottoms.

Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
342 Madison Ave.

HOUSTON
M & M Bldg.

TULSA
Thompson Bldg.

CHICAGO
10409 S. Western Ave.

LOS ANGELES
6399 Wilshire Blvd.

REPRESENTATIVES:
SEATTLE: Nebar Supply Company, 3000 Western Avenue
MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
TORONTO: Lytle Engineering Specialties, Ltd., 69 Eglington East
VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
CARACAS: Sinclair Spence, C.A., Edificio Galipan
ENGLAND: Whessoe, Ltd., Sales: 25 Victoria St., London S. W. 1
Whessoe, Ltd., Works: Darlington, County Durham

For more data on advertised products, use Readers' Service Cards, last page.

For wider adaptation . . . and unmatched Service Life . . . . .

Vogt GENERAL GP PURPOSE* VALV

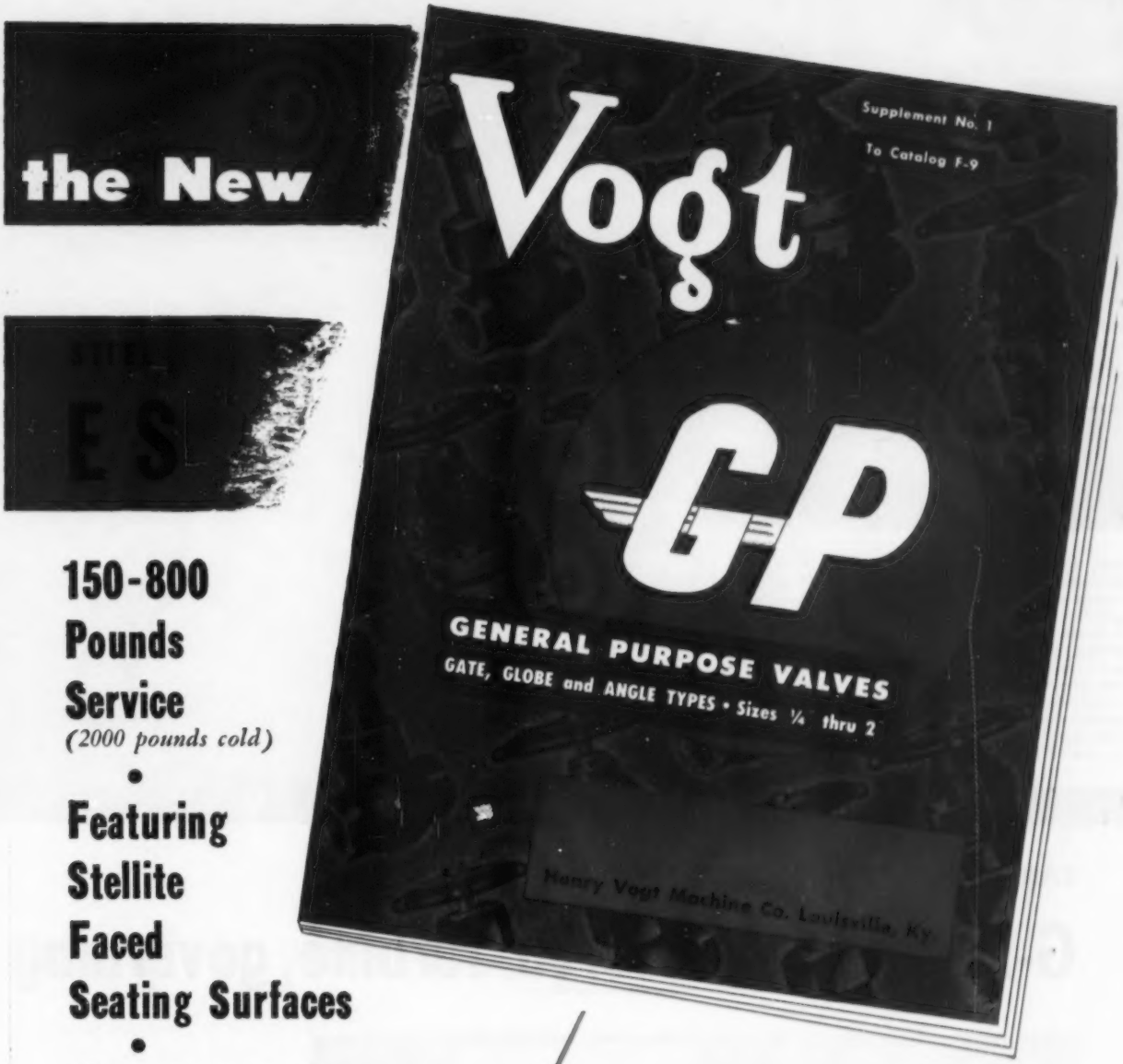
We invite you to inquire into the savings which the new line of Vogt GP Drop Forged Steel Valves can make possible in your operations. Not only do their many unique and exclusive features make them more economical of operation, but their broad adaptability to so many industrial applications permits a substantial reduction in operating overhead. Service life, too, is enhanced with Stellite faced seating surfaces which are available at no extra cost along with many other trims.

FREE
Supplement No. 1 to Vogt Catalog F-9

* GP Valves completely fill the demands of industry for a line of compact, lighter weight, shorter face-to-face valves.

Still retaining the safety and ruggedness inherent in a wrought material, these new forged steel screw and socket weld end valves, in sizes from ¼" through 2", are rated 800 pounds at 850°F. and 2,000 pounds at 100°F.

the New



150-800 Pounds Service
(2000 pounds cold)

•

Featuring Stellite Faced Seating Surfaces

•

Sizes ¼" to 2"

This 32-page catalog illustrates and gives complete specifications on 11 types of the new Vogt GP forged steel gate, globe and angle valves. Send for your free copy — for ready reference in purchasing. Use the coupon for convenience.

HENRY VOGT MACHINE CO.
LOUISVILLE 10, KENTUCKY

SALES OFFICES: New York, Philadelphia, Cleveland, Chicago, St. Louis, Charleston, W. Va., Cincinnati, Dallas, San Francisco

HENRY VOGT MACHINE CO.
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Please send copy of New Vogt Catalog Supplement No. 1 to . . .

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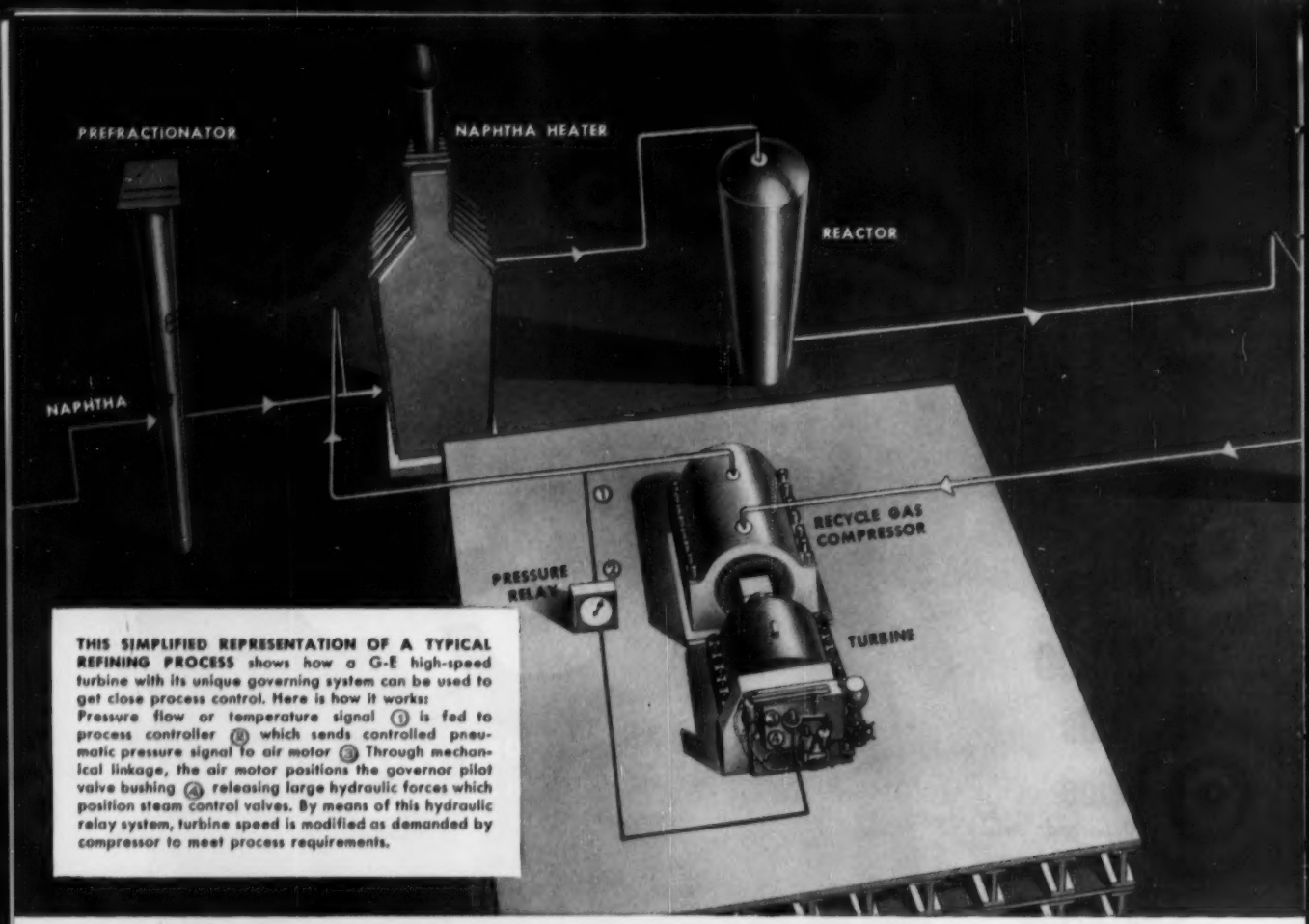


THIS SIMPLIFIED REPRESENTATION OF A TYPICAL REFINING PROCESS shows how a G-E high-speed turbine with its unique governing system can be used to get close process control. Here is how it works: Pressure flow or temperature signal ① is fed to process controller ② which sends controlled pneumatic pressure signal to air motor ③. Through mechanical linkage, the air motor positions the governor pilot valve bushing ④ releasing large hydraulic forces which position steam control valves. By means of this hydraulic relay system, turbine speed is modified as demanded by compressor to meet process requirements.

EASILY INCORPORATED INTO YOUR PRESENT SYSTEM . . .

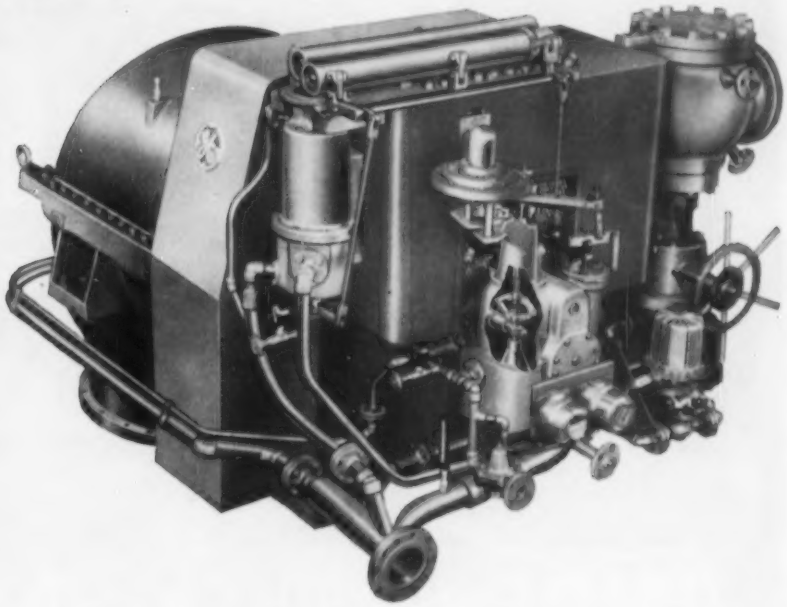
G-E position-restored turbine governing

HERE IS THE SMALL TURBINE AND SUPERCHARGER DEPARTMENT MARKETING TEAM that can show you how to apply all the advantages of G-E high-speed turbine governing to your process operations. R. E. Donnelly, Manager—Marketing, discusses a possible petroleum application with H. J. Chase, Manager—Engineering, at left, and C. B. Seelig Manager—Sales, center.

HIGH-SPEED TURBINES FOR ALL PROCESS APPLICATIONS

- PETROLEUM
- CHEMICAL
- PETROCHEMICAL
- STEEL

TURBINES FOR HIGH-SPEED COMPRESSORS . . .



THE GENERAL ELECTRIC POSITION-RESTORED GOVERNOR, shown cutaway above, utilizes the best features of both mechanical and hydraulic control. Heart of the system is a fly-ball-positioned, rotating pilot valve, which releases a tremendous store of power to position the steam inlet valves. The released power is controlled through feedback by a weight-biased mechanical-linkage that repositions the pilot-valve bushing only in direct response to movement of the steam-inlet valves, rather than in response to a force generated by the movement of the valves.

can give you close process control

In process industries, if quality-control and peak production are to be maintained, turbines that drive high-speed compressors and blowers must have close, accurate governing in response to load requirement and the slightest variations in steam conditions.

To help you get more precise control, all G-E high-speed turbines have a position-restored governor. It is an oil-relayed, mechanical-type control device that automatically matches turbine speed to process demands.

This governor will operate accurately and effectively with any recycle controlling system because the mechanical-linkage can be adjusted to match the complete output-signal range of any process controller. The G-E governor can be incorporated with a typical control system as shown in the schematic drawing.

FOR CLOSE PROCESS CONTROL the unique design of the G-E high-speed turbine governor offers these advantages:

Accurate signal relay results since speed changes are made through a weight-biased mechanical-linkage which repositions the pilot valve bushing only in direct response to movement of the steam-inlet valve. The system is not affected by oil-flow forces and is quick to respond to changes in process requirements.

Direct, precise speed settings are therefore possible because turbine response to process requirements is not dependent on force balance between springs and signal pressure.

Completely integrated governing responds not only to process demand but also to steam pressure or temperature changes, which must be factored in for close process control.

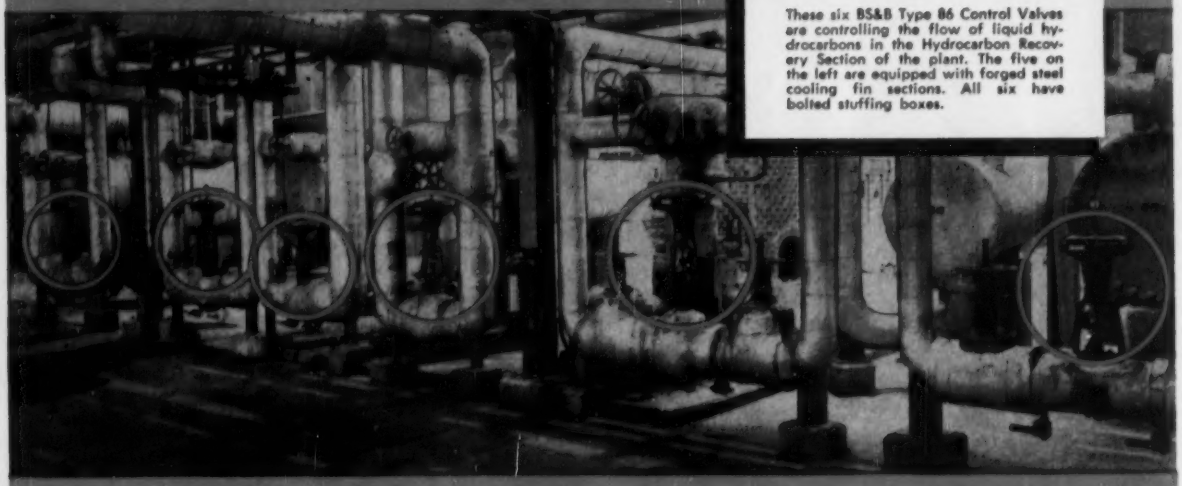
Position-restored governing keeps the system in near-perfect equilibrium, practically eliminating speed surges and turbine "hunting." Be sure to see how this governing system may be used to advantage in your process operation.

For more detailed information, contact your nearest General Electric Apparatus Sales Office or write General Electric Company, Schenectady 5, N. Y. In Canada, contact Canadian General Electric Company, Limited, Toronto. 241-5

Progress Is Our Most Important Product

GENERAL ELECTRIC

Where *Dependability* Counts Most...



These six BS&B Type 86 Control Valves are controlling the flow of liquid hydrocarbons in the Hydrocarbon Recovery Section of the plant. The five on the left are equipped with forged steel cooling fin sections. All six have bolted stuffing boxes.

BS&B Automatic Controls Get The Job!

One of the largest petro-chemical plants in the world is that of the National Petro-Chemicals Corporation at Tuscola, Illinois. This $50,000,000 plant extracts the heavier hydrocarbons from natural gas and converts them into fuels and chemicals used in the manufacture of plastics, synthetic fibers, fertilizers, detergents and dozens of other useful products.

This plant is largely automatic, thanks in large measure to numerous BS&B Pressure Control Pilots and Liquid Level Control Pilots—and to *more than 200* BS&B Automatic Control Valves in plant service!

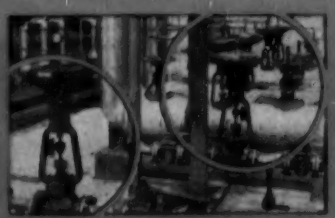
Valves range in size from ¾" to 8", many supplied with special body materials. Body types range from screwed globe cast iron valves to 600# ring type joint, flanged globe steel valves. Some were supplied with Haveg Bodies.

Valve trim included such materials as stainless steel and Hastelloy "B". Several valves in strategic plant locations were furnished with our Type Y Side Handwheels for emergency operation in the event of an operating medium failure. Some, destined for high temperature operation, were equipped with finned cooling sections. Many were furnished with valve positioners, either yoke mounted or mounted in the diaphragm case.

But however specialized the application, each BS&B Control was selected for the job because of its *dependability*...so vital to the successful operation of so complex a plant!

Next time you have a project in the planning stage, why not discuss the controls aspect of it in *strictest confidence* with our representative to be sure you get the *very best* controls for the job to be done?

For Better Regulation of Pressures, Temperatures, Liquid Levels or Flow, Equip Your Process With BS&B AUTOMATIC CONTROLS and SAFETY HEADS!



These six Type 86's, also with bolted stuffing boxes, are controlling the flow of fuel gas to the still heater in the Hydrocarbon Recovery Section of the plant.

These three BS&B Control Valves are on ethylene service in the Ethylene Section of the plant. On the left is a BS&B Type 73 DC Pressure Balanced Control Valve. In the center is a Type 86 with Finned Cooling Section and Jumbo Diaphragm. On the right is a Standard Type 66 with Large Topworks.

BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-F11
7500 East 12th Street Kansas City 26, Missouri

wherever precise flow
measurement is critical . . .

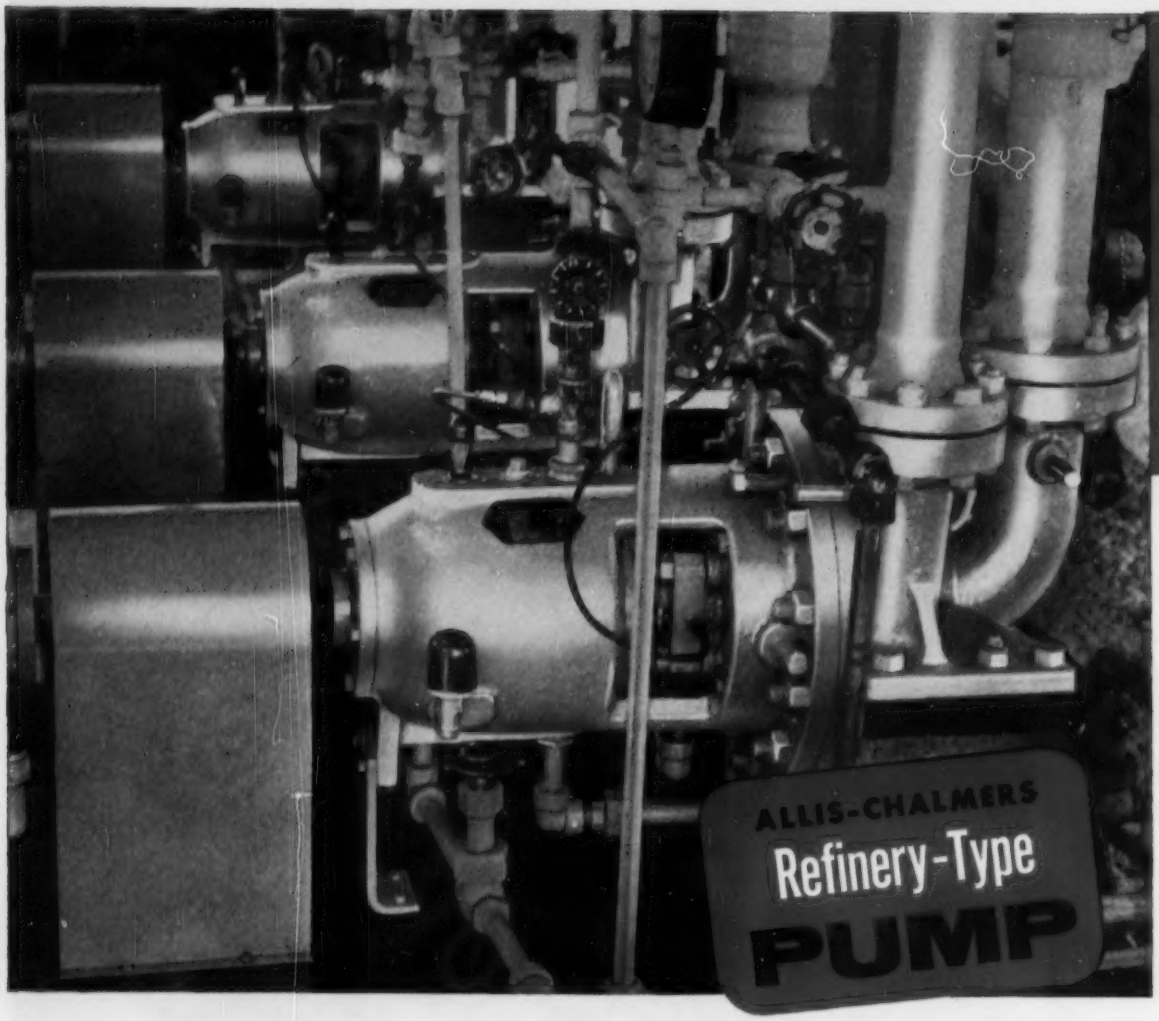
Potter TURBINE TYPE FLOWMETER

ACCURATE, DEPENDABLE POTTER FLOWMETERS are being specified by more and more chemical processors each year for jobs that demand high reliability, high precision, low maintenance, extreme control precision. Available in sizes from 1/8" to 6" units, they measure caustics, acids, corrosives, unstable compounds, suspensions, super-refined liquids and other hard-to-handle liquids at temperatures up to 1200°F and at pressures to 35,000 psi. Easily incorporated into complex control systems because of their linear output, Potter sensing units produce a signal that can be telemetered, fed into digital information handling systems, or measured directly to indicate or control flow rate or total flow.
Find out how this unique approach to flow measurement can help solve your flow-control problems. Write for Bulletin S-1.

POTTER AERONAUTICAL COMPANY • Route 22 • Union, N. J. • Phone MUrdock 6-3010
Makers of "Potter Engineered" products

For more data on advertised products, use Readers' Service Cards, last page.

Sun Oil uses



Ample Reserve Strength in Every Detail of Construction

Sealing — Various types of packing and mechanical seals or combinations of both can be obtained to suit the application.

Cooling of stuffing box and bearings can be provided by water or oil, in five separate places. Water-cooled pedestal available for extremely high temperature operation.

Wearing rings, front and rear, are provided on both impeller and casing.

Shaft and bearings are of exceptionally heavy design to reduce deflection and vibration, assure long wear, low operating costs.

Throat bushing and base ring are renewable. Close fit on shaft reduces infiltration into stuffing box. Cannot blow in or out.

Double volute casing used on pumps above 400 gpm greatly reduces deflection forces. Low NPSH design successfully handles highly volatile liquids at high temperatures.

ALLIS-

eleven of these pumps

Where Service Continuity Is Essential

ELEVEN of these Allis-Chalmers refinery-type pumps are installed on a variety of continuous duty applications at a refinery of the Sun Oil Company, Limited. They are top suction, water-cooled units with standard high temperature packing. These pumps have the stamina to keep going on the toughest applications for years without down time. Every construction detail has been carefully engineered to provide ample reserves of strength and durability.

wide choice of materials and features

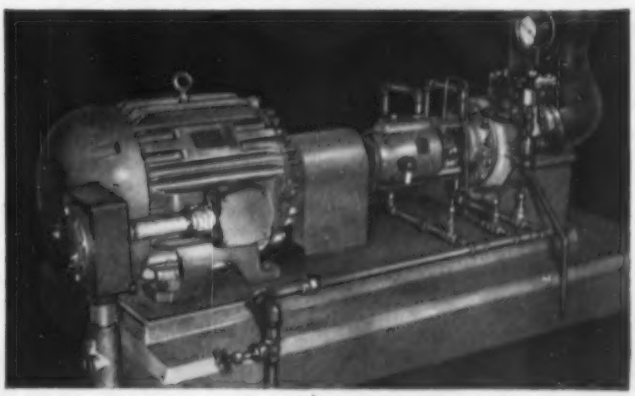
The Allis-Chalmers refinery pump can be fitted to suit your requirements exactly. Practically any material normally used in pumps may be specified. Stuffing box takes packing, mechanical seal or both. Cooling water or oil may be used in five separate places, so you can select exactly the cooling arrangement for your particular needs. Suction may be at top or on end.

get complete information

Your nearby Allis-Chalmers representative will be glad to help you with your refinery pump problems. Or write for Bulletin 52B7775. Allis-Chalmers, Milwaukee 1, Wisconsin. A-4557

get complete unit / pump motor control

Allis-Chalmers will supply a complete pumping unit — pump, motor and control — engineered to work together and with pump and motor mounted on a single base plate ready for installation. You save engineering time because you don't have to match components from different manufacturers. You save purchasing time — only one order. And, most important, you are sure that the components will work together to give you long life at low operating cost. The complete unit is covered by a single guarantee backed by Allis-Chalmers well-known customer satisfaction policy.



A-C CHALMERS

Only Childers Jacketing Offers LAP-SEAL

LAP-SEAL is a series of eight ribs rolled into the underlapping edge of the jacketing.

LAP-SEAL makes more positive weather seal.

LAP-SEAL saves labor—2" ribbed edge eliminates measuring for circumferential lap.

LAP-SEAL (patent applied for) is an exclusive "plus" available on all Childers Jacketing at no extra cost.

Cutaway view shows how jacketing goes on right over the insulation. Tests show Childers is the lowest cost of any permanent metal jacketing that is available today.

Only pliers and pocket knife needed to apply easy-to-handle Childers Aluminum Jacketing

Best method of applying jacketing is with aluminum strapping and seals. Other method is to use sheet metal screws.

Aluminum strapping can be pulled tight enough with just pliers. Lugs are then bent over and fastening is complete.

Eastern States Petroleum's two-man crew covers insulated lines, even L's and bends—using light-weight, weatherproof aluminum jacket.

Childers Jacketing for insulated lines, made of .006" 3S alloy aluminum, was used to cover thousands of feet of line in Eastern States Petroleum's Houston plant.

As it does in over 1000 other plants in all 48 states and many foreign countries, Childers Jacketing helped save Eastern States many expensive hours of application and maintenance time.

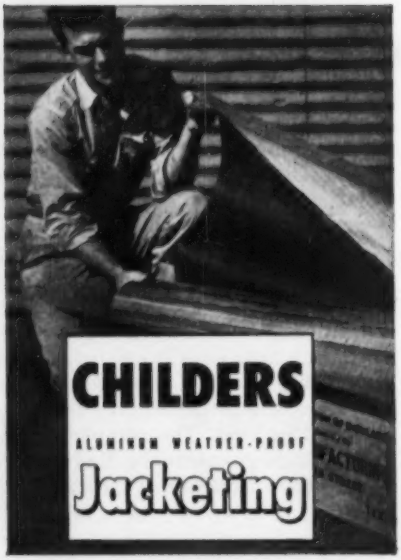
In fact, tests show this: Two men, working with Childers Jacketing for the first time, can cover more feet of insulated line in a day than with practically any other kind of covering. This means real savings in application costs.

The cost is low, too. You can actually put aluminum jacketing on your lines for less than the cost of the cheapest weatherproofing when one paint job is considered.

Immediate shipment from our large factory stocks can eliminate costly delays in construction or plant improvement schedules.

Try this low cost protection in your plant. Write today for engineering data and information about how you can order a 400 sq. ft. roll to test on one of your insulated lines. No obligation. Address: Childers Manufacturing Company, Department PR-29, 3620 West 11th Street, Houston, Texas.

Engineering representatives in most cities to work with you on jacketing problems.



Childers Jacketing arrives on the job in convenient rolls 4 feet wide and 100 feet long—easy for one man to handle. Jacketing comes with or without a moisture barrier attached to the back of the .006" aluminum. Rolls are well protected for field storage if kept dry. Boxes light enough for one man to carry. (Adv.)

How Zeolite System at
Public Service Company of Colorado

"Irons Out"

Water Irregularities Caused by Fluctuating Loads

DENVER'S UNUSUAL CLIMATE causes unusual water conditioning problems at Public Service Company of Colorado's Zuni Station. Steam from this station is used to heat downtown Denver buildings. Denver's balmy midday climate — except in the two cold months of the year—is the cause of troublesome load fluctuations.

The lime-soda-phosphate system installed in this plant by Allis-Chalmers in 1949 was one of the most modern in the country at the time. It is ideal for extremely high loads in the morning and evening, but requires careful adjustment to handle the low loads around noon.

Public Service of Colorado has decided to modernize to take advantage of developments in "hot lime–hot zeolite" systems since the original installation. The zeolite part of the system acts as its own corrective when loads drop, "ironing out" hardness irregularities in the lime effluent and eliminating need for manual adjustments. The new system will provide more consistent operation and lower hardness. The only chemicals needed are lime and salt, holding operating costs to a minimum.

The changeover, being handled completely by Allis-Chalmers, consists of adding zeolite softeners to the original equipment furnished by A-C.

Next time you have a water problem — or want to consider modernization — take advantage of Allis-Chalmers water conditioning experience. For information, call the A-C office nearest you or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

WATER CONDITIONING—CHEMICALS, EQUIPMENT, SERVICE—FOR OVER 25 YEARS

A-C ALLIS-CHALMERS

A-4848

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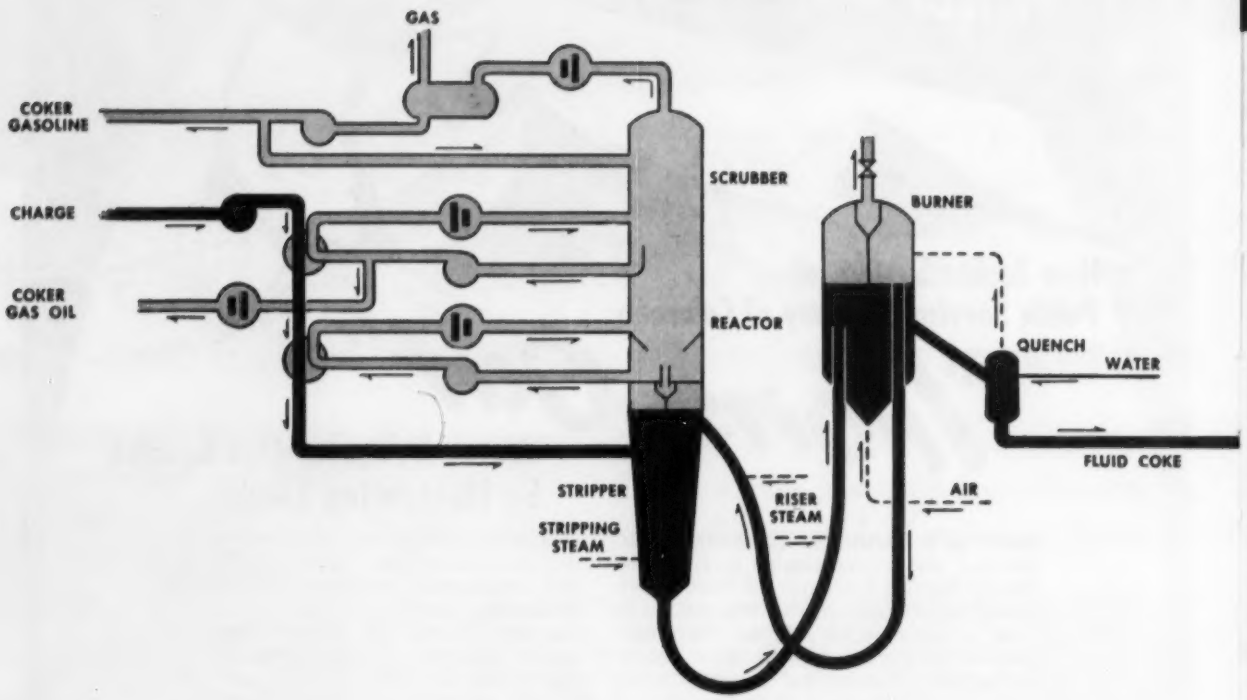
fluid

its production...



IN THIS latest application of the fluidized-solids technique, developed by Esso Research and Engineering, heavy residua and asphalts can be converted to gas, oil and coke.

As shown in the flow diagram above, finely divided coke particles flow between two vessels—a burner and a reactor. In the burner, part of the coke stream is burned to supply the heats for vaporization, cracking and losses. When this hot coke meets the feed in the reactor, coking results and the liquid products are flashed off.

Coke particle size ranges between 75 and 150 microns and the coke itself is a clean, dustless solid. The feed is preheated through two fractionator (scrubber) pump-around systems. In the reactor it contacts the hot coke flowing from the burner. Coke is formed as the fluidized bed moves down into the stripper section where steam removes any remaining volatiles. The stripped coke then flows into the burner where, in contact with air, approximately 5 per cent by weight of the charge is burned. The coke inventory in the unit is fixed and the excess is removed as product coke which is cooled by water spray before flowing to storage.

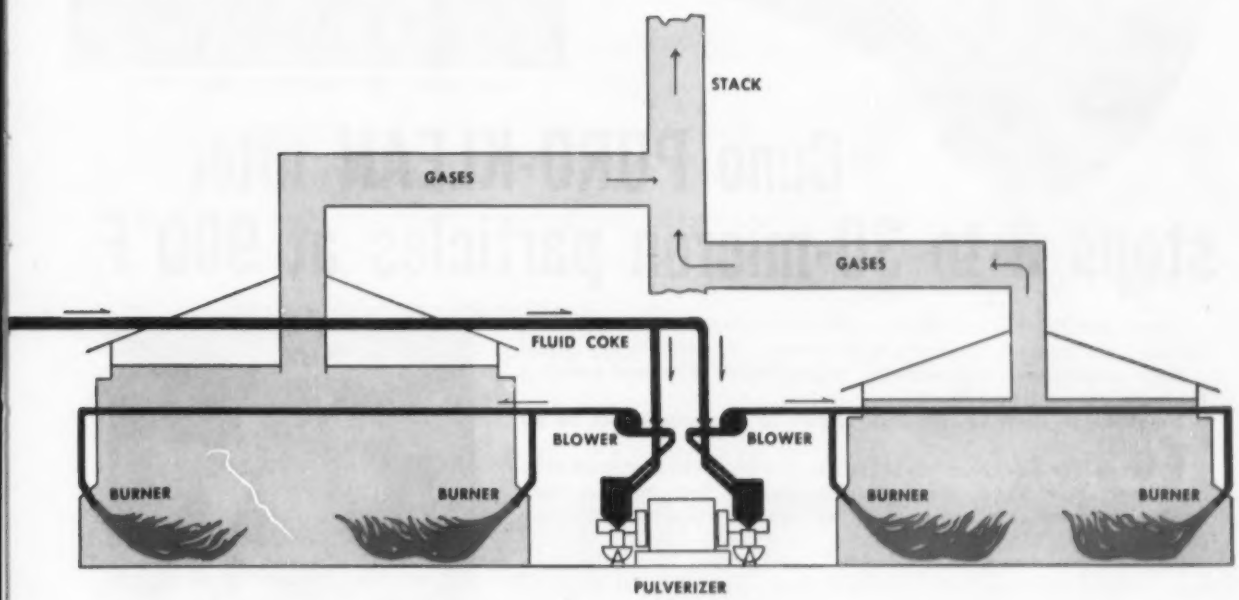
The vapors from the reactor pass into the scrubber-fractionator section where they are separated into gas, gasoline and gas oil.

FOSTER

For more data on advertised products, use Readers' Service Cards, last page.

coke

...and utilization



THE USE of fluid coke as a fuel is illustrated in the above simplified diagram of two heaters designed by Foster Wheeler for a large oil company. They will supply the heat requirements for the atmospheric and vacuum sections of the highest capacity crude distillation unit in the world, having a combined heat absorption capacity of 336,400,000 btu per hour.

The pulverizers which reduce the particle size of the fluid coke before it is burned in the furnaces, as well as the pulverized coke burners, are also of Foster Wheeler design.

Designs are also available for the burning of fluid coke in steam generators.

Foster Wheeler's experience in the design of equipment for both the *production* and *utilization* of fluid coke will be of value to any process plant interested in converting heavy residua into cracking stock and making effective use of the resulting solid fuel. For further details on this process, or for proposals to meet your specific requirements, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

FW WHEELER

LONDON
NEW YORK
PARIS
ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

NEW!

Porous stainless steel (15-diameter magnification)

Cuno PORO-KLEAN filter stops 3-to 30-micron particles at 900°F

Cuno's new PORO-KLEAN offers true micronic filtration at temperatures that melt tin, bismuth, cadmium, lead or zinc.

High temperatures, high viscosity, high pressure drops and corrosive fluids don't faze this new filter.

It's all metal—absolutely lint-free. There's no contamination of the filtered fluid.

It's strong. PORO-KLEAN filters already in operation take a pressure drop of 1500 psi. PORO-KLEAN porous stainless steel has been used for structural parts in aircraft to achieve boundary layer control and transpiration cooling.

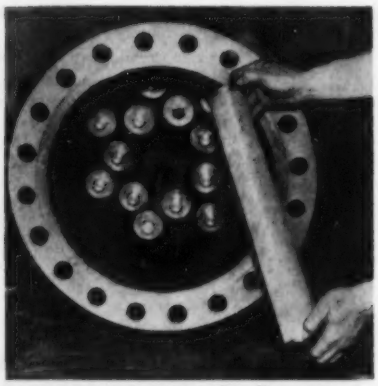
It's corrosion resistant. Standard in 316 stainless steel. Low carbon content (0.03 to 0.05% max.) prevents carbon precipitation at welds or during fabrication.

It's easily cleaned—in place, by backwashing with pre-filtered fluid or inert gas; or, when removed, with suitable solvent. May be sterilized with live steam for food or drug processing; or will filter rust and scale from steam used for other cleaning or sterilizing.

Its porosity is closely controlled. Four standard grades cover the range from 3- to 30-micron statistical particle retention.

Standard designs. For most applications standard housings and elements are available.

Get all the facts on Cuno's new PORO-KLEAN filter for your chemical or process applications. Write Cuno Engineering Corporation, 33-11 South Vine Street, Meriden, Conn. 5.3



THIS PORO-KLEAN FILTER handles 180 gpm of naphtha at 400°F. Operating pressure: 700 psi ASME Code with 5 psi pressure drop. It's cleaned by back-flushing with nitrogen. Cell-type PORO-KLEAN filter elements (large picture at top) have large surface area. This unit is 54" L x 9" O.D. and is designed for 1500 psi pressure drop and 550°F.

CUNO **ENGINEERED FILTRATION**

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous metal)

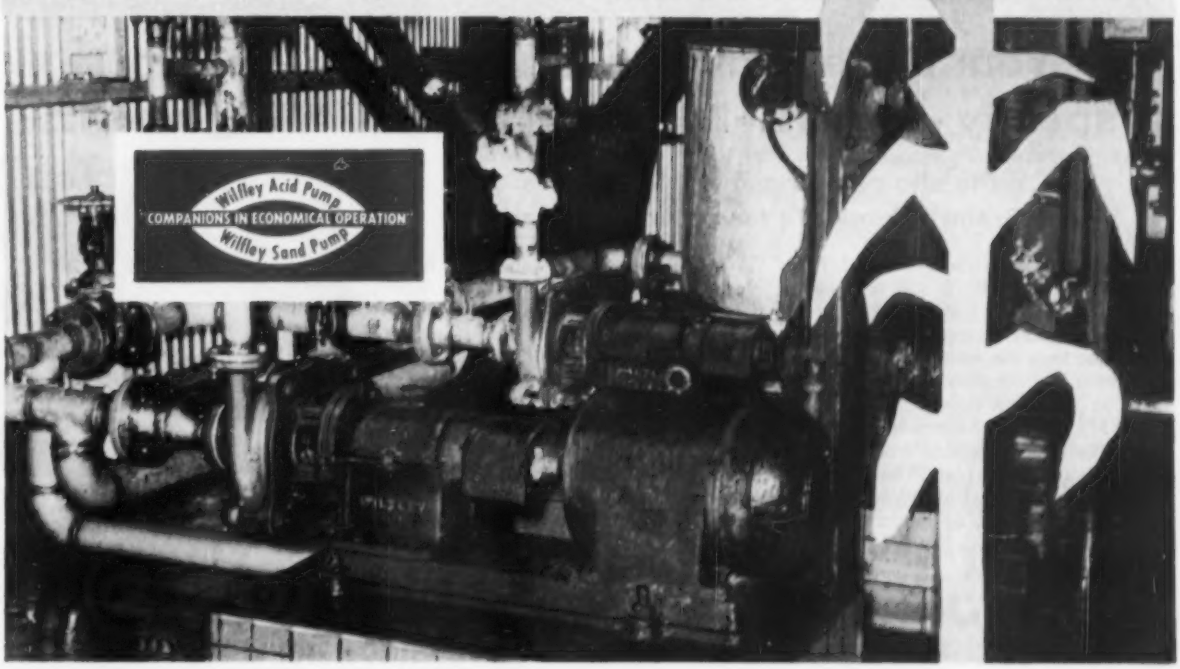
WILFLEY

helps the corn grow tall!

Fertilizer is one of the many end-products that originate in modern chemical plants. In many of these plants **WILFLEY ACID PUMPS** are a vital factor in the production of ammonium nitrate—a basic ingredient. Wherever installed, highly efficient Wilfley pumps reduce pumping costs and increase production . . . operate without attention, delivering trouble-free performance on round-the-clock schedules. Available with pumping parts of the machinable alloys as well as plastic to meet all requirements. Individual engineering on every application. Write or wire for complete details.

A. R. WILFLEY and SONS INC. Denver, Colorado, U.S.A. New York Office: 1775 Broadway, New York City

Photo shows Wilfley Acid Pumps handling **AMMONIUM NITRATE at HIGH HEADS**



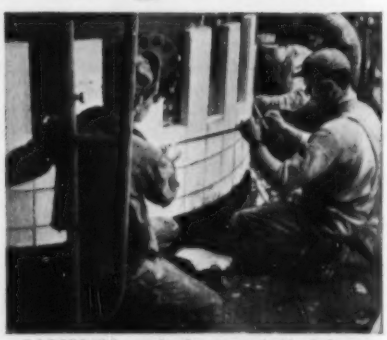
J-M 85% Magnesia is lightweight . . . easy for workmen to install half-sections on this 10″ steam line. Insulation work at the Grace Chemical plant was performed by Young Sales Corporation of St. Louis. Engineering and construction was directed by Foster Wheeler Corporation of New York.

Your Btu's and dollars go further when you specify **Johns-Manville 85% Magnesia**

. . . the choice of insulation engineers at Grace Chemical's new Memphis plant

INDUSTRY'S LONG-TIME standard for temperatures to 600F is still your best insulation buy. For J-M 85% Magnesia provides high insulating value, easy application, long life, initial low cost and minimum maintenance. That's why insulation engineers consistently specify J-M 85% Magnesia for modern installations like Grace Chemical's new anhydrous ammonia-urea plant. That's why it will pay you to specify J-M 85% Magnesia for your new plant or modernization program.

To assure you maximum value from your insulation dollar, Johns-Manville gives you complete drawing-board-to-job-site service. You get expert recommendations by the world's most experienced insulation engineers . . . plus expert installation by authorized J-M Insulation Contractors. Write today for further information on J-M 85% Magnesia and Johns-Manville's unmatched facilities to solve your insulation problems. Address Johns-Manville Box 60, New York 16, N.Y. In Canada, Port Credit, Ontario.



J-M 85% Magnesia also comes in block form. Here you see it being applied to a vertical drum at a New Jersey petroleum refinery.

Johns-Manville *first-in* **INSULATION**

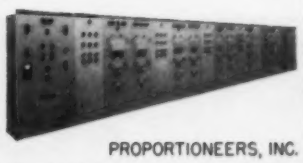
MATERIALS · ENGINEERING · APPLICATION

For more data on advertised products, use Readers' Service Cards, last page.

THE OCTANE EQUATION

TECHNICAL DATA

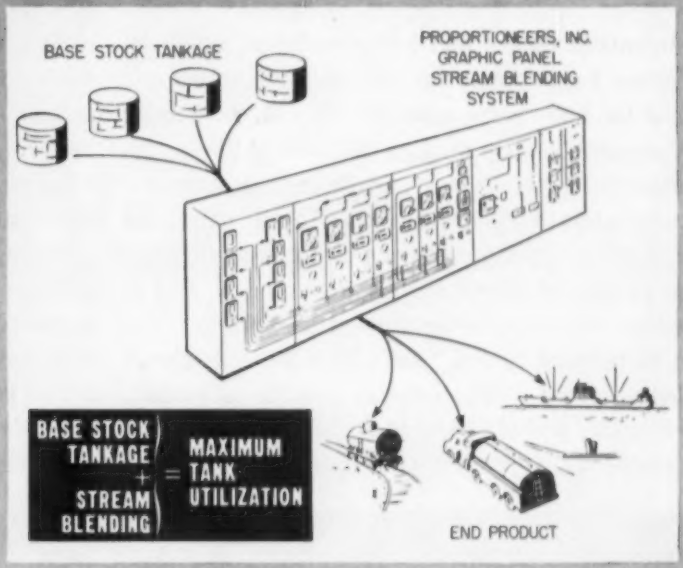
Shell Products Pipe Line was one of the first to recognize the flexibility of operation made possible by continuous automatic "stream" blending. This company has installed B-I-F Industries' equipment at their Wood River Pump Station for blending finished gasolines directly to their North and East lines respectively. Preset formulations at all flow rates of finished product demanded by the pipeline are automatically maintained by multiple component blenders . . . to blend six gasoline base stocks, T.E.L., dye, and gasoline additives to pipe lines without intermediate tankage. Full particulars on this installation are available



PROPORTIONEERS, INC.
STANDARD PANEL STREAM BLENDER

This equipment can be arranged to handle any type of problem and any number of components at flow rates ranging from 150 barrels per hour to the limit of modern transfer pumping equipment and pipe line sizes.

Units are available for stream blending other finished products (solvents, diesel fuels, lube oils, heating oils, bunker fuels, asphalt cut-backs, etc.) with equal facility and dependability. Our diversified product line . . . for metering, feeding and controlling any of the petroleum or petrochemical processes . . . is designed to make money for you. Let us show you how!



THE PROBLEM

As automobile manufacturers continue their current trend toward higher-compression engines, refiners face an ever increasing demand for premium motor fuels. New processes, or improvements on existing processes, are being installed to meet these demands. The fuel outlook is further complicated by the fact that the automotive industry is developing engines requiring lower grade fuels . . . and predictions indicate these engines will be in use by 1960.

THE SOLUTION

The fast growing petroleum industry is quick to recognize and adopt equipment which facilitates product movement . . . and continuous automatic blending gives refinery operation the flexibility it needs to keep pace with progress. Stream blending not only provides tailor-made hydrocarbons, but minimizes the need for intermediate tankage and allows specific seasonal market conditions to be met without costly inventory change-overs. B-I-F Industries, Inc. is the leading manufacturer of this type of equipment . . . and boasts the greatest number of diversified installations.

Features

- ★ *Complete stream blending systems, utilizing unitized construction, are available . . . factory-tested under field conditions.*
- ★ *All systems are electrically and mechanically interlocked to provide "fail-safe" operation under all job conditions.*
- ★ *Our "Blue Chip" products are designed, engineered, manufactured, assembled and tested . . . under one roof . . . assuring you of outstanding product quality and performance.*

"THE BEST COSTS LESS"

For engineered recommendations, write to **Proportioneers, Inc.**, Division of B-I-F Industries, Inc.

B-I-F INDUSTRIES

PROVIDENCE, RHODE ISLAND

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • BUILDERS-PROVIDENCE, INC. • OMEGA MACHINE CO.

METERS
FEEDERS
CONTROLS

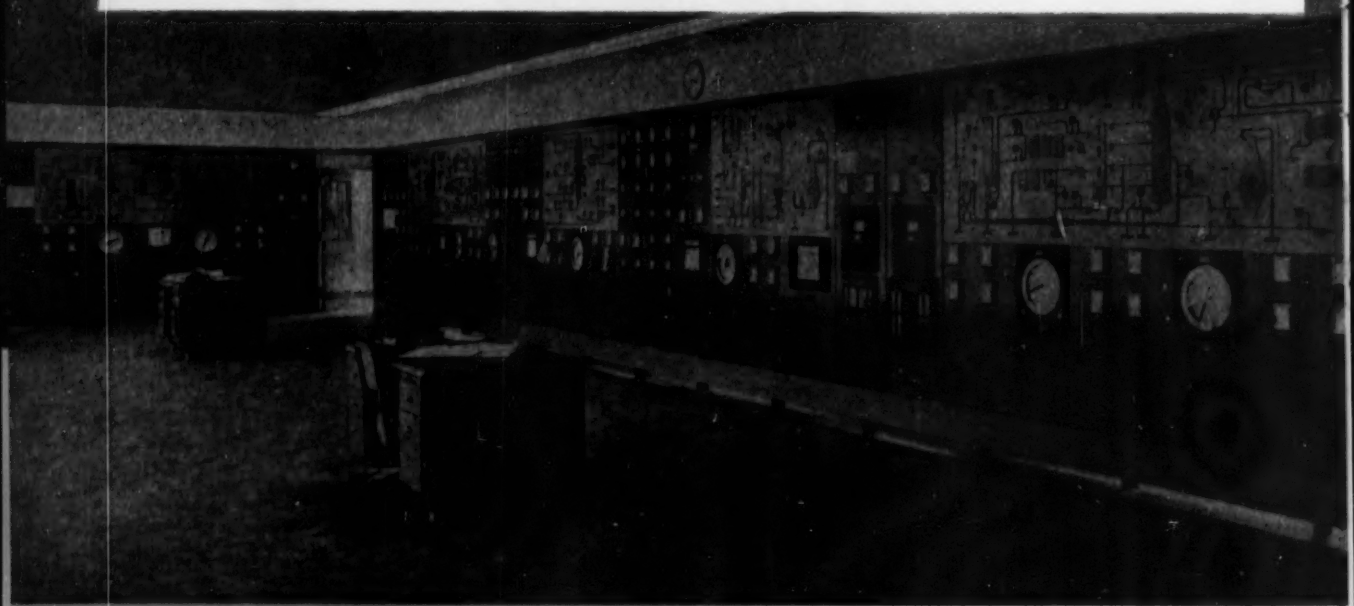
For more data on advertised products, use Readers' Service Cards, last page.

Automation is Over 21 —at M. W. Kellogg

Automatic control and instrumentation, which together have coined the new word "automation", are far from being new with The M. W. Kellogg Company. Largely through the work of the Instrument Section of Kellogg's Engineering Department, automation has long since come of age in petroleum refineries. It has been paying off for years in terms of increased production, higher quality, and in added safety and better working conditions.

In refinery control rooms, like the one shown below, every critical process variable is plotted, recorded, and observed at a glance . . . including temperatures, pressures, flow, and physical and chemical characteristics of the refinery process stream. Instruments now under development, using radioactive isotopes, can even peer through the heavy walls of high pressure vessels—and thus avoid the weakening of vital equipment caused when walls have to be drilled for conventional instruments.

The M. W. Kellogg Company's Instrument Section continues to work closely with all instrument manufacturers toward the development and application of systems which can improve refinery operations. It is an important part of the over-all service Kellogg can offer in designing your future petroleum or petrochemical facilities.



Control room of North Star Oil Limited refinery, St. Boniface, Manitoba—built by The Canadian Kellogg Company, Limited.

M KELLOGG W

REFINERY PROCESS DIVISION

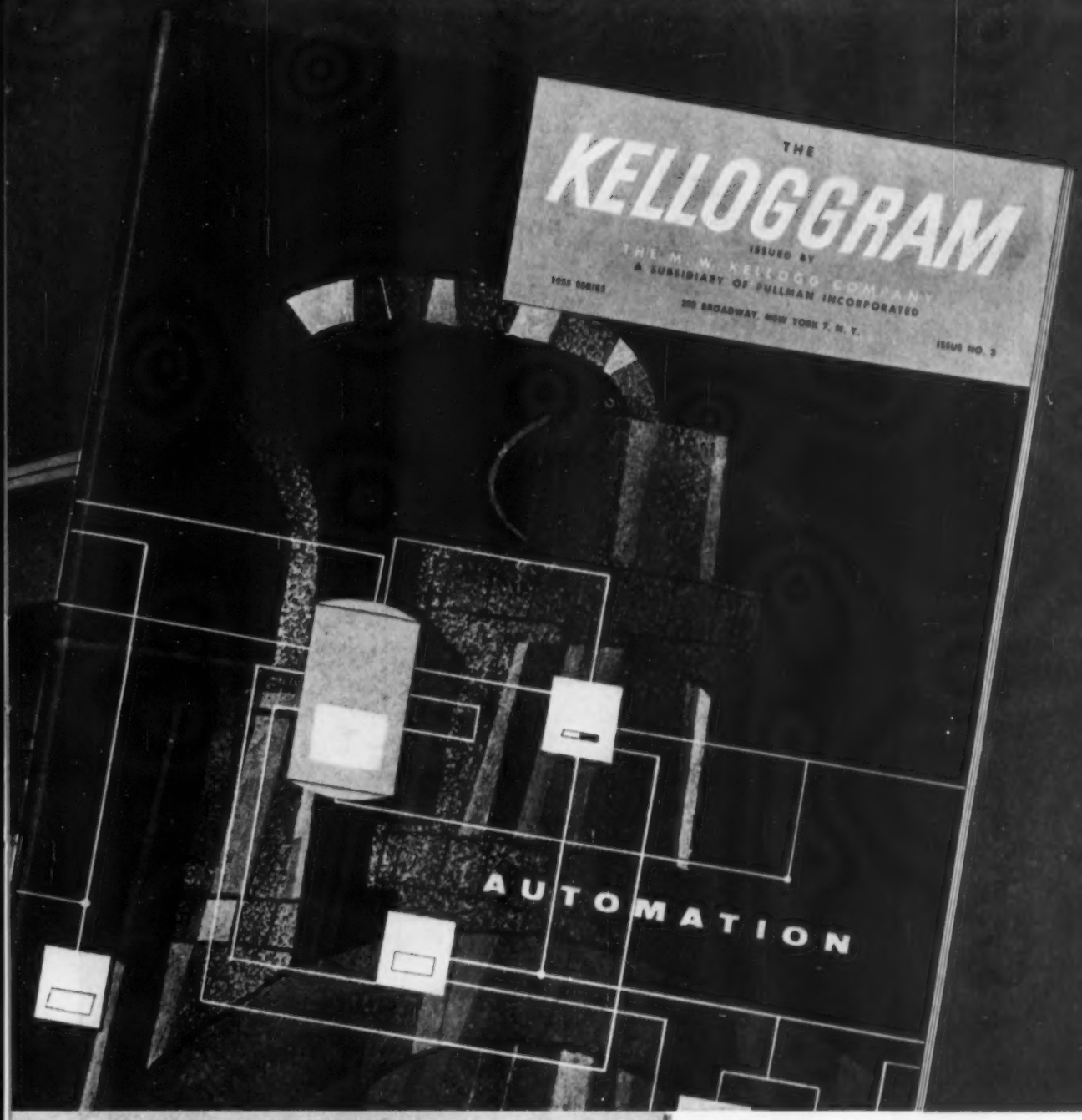
THE M. W. KELLOGG COMPANY

225 BROADWAY, NEW YORK 7, N. Y.

In Canada: The Canadian Kellogg Company, Limited, Toronto.

In Europe: Kellogg International Corporation, London

SUBSIDIARIES OF PULLMAN INCORPORATED



16-page booklet gives the facts

The M. W. Kellogg Company's No. 3, 1955 Kelloggram graphically explains, step by step, exactly what automation is, what it does, and how it can be employed by the petroleum refining and petrochemical industries to improve plant operating efficiency and product quality.

An easy-to-understand treatise of a highly complex subject, this 16-page booklet, illustrated with full-color diagrams, includes sections on gamma ray instruments, data reduction systems, electronic instrumentation, stream analyzers, and high pressure instruments.

A limited number of copies of this Kelloggram on automation are still available. The coupon will help expedite your request.

The M. W. Kellogg Company
225 Broadway, New York 7, N. Y.

Send copy of your 16-page Kelloggram (No. 3, 1955) which gives the complete story of automation and its application in petroleum refineries and petrochemical plants.

Name _____

_____
(Title, if any)

Company _____

Address _____

_____

_____

PR 11/55

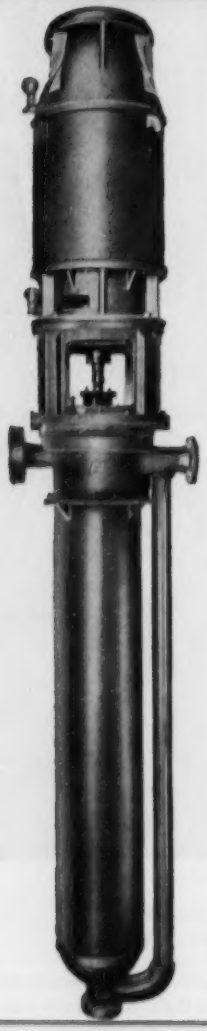
Bingham

DOUBLE VOLUTE DOUBLE CASE "HI-PRESS" PUMP

UNSURPASSED

FOR EXTREMELY HIGH PRESSURES

HOT or COLD SERVICES



"DOUBLE VOLUTE" DESIGN PROVIDES HYDRAULIC RADIAL BALANCE OF ROTATING ELEMENT... NO "SIDE PUSH"... ELIMINATES WEAR AND SEIZURE

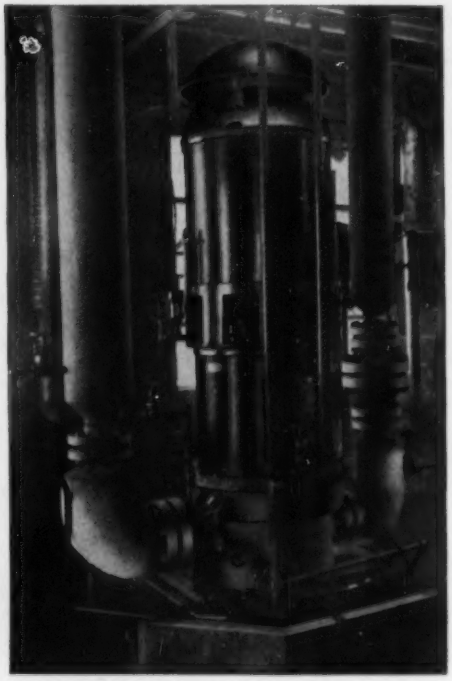
The "Double Volute" construction of Bingham Multistage "Hi-Press" Pumps insures perfect radial balance of the rotating element, under all operating conditions... completely eliminating wear between rotating and stationary parts. "Double Volute" construction permits maximum use, without exceeding normal clearances, of non-corrosive metallurgy—particularly austenitic steels—normally considered dangerous on account of their galling and seizing characteristics.

This feature also eliminates shaft deflection, permitting **mechanical seals** to establish and maintain a uniform track between contacting faces. This prevents leakage and seal face wear, resulting in **long seal life.**

"Double Volute" design also permits the pumpage to be discharged from the inner into the outer case through *two nozzles* located 180° apart. For hot service, this feature provides adequate circulation of pumpage between the two cases, insuring a uniform temperature rise in all parts—thereby eliminating distortion due to temperature changes.

Location of suction and discharge at top of pump case is particularly suitable for low NPSH conditions.

Bingham "Hi-Press" Pumps have established an exceptional record of long life and trouble-free service wherever they have been installed.



One of a group of Bingham "Hi-Press" Pumps in a large East Coast refinery handling 750° F. reduced crude oil at a differential head of 2000 feet.

Write your nearest Bingham office for full information.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: **2800 N. W. Front Avenue, Portland 10, Oregon**

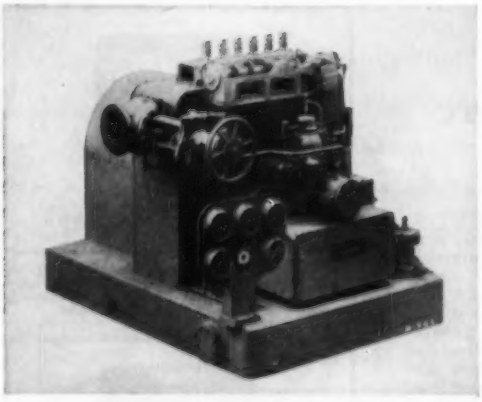
Factories: **Portland, Ore. • Vancouver, B. C., Canada**

SALES AND SERVICE OFFICES

BOSTON, MASS.	PITTSBURGH, PA.
CHICAGO, ILL.	SAN FRANCISCO, CALIF.
DENVER, COLO.	SEATTLE, WASH.
HOUSTON, TEXAS	ST. LOUIS, MO.
KANSAS CITY, MO.	ST. PAUL, MINN.
NEW ORLEANS, LA.	TULSA, OKLA.
NEW YORK CITY, N. Y.	TORONTO, ONT., CAN.
PHILADELPHIA, PA.	VANCOUVER, B. C., CAN.

NIGHT VIEW of Cities Service Refinery, Lake Charles, La.

Worthington steam turbines keep refineries on stream



WORTHINGTON TYPE S MULTI-STAGE STEAM TURBINE provides drive for generators, pumps, compressors where dependability, close speed regulation, and economy are essential.

Dependable prime movers are a must where breakdowns can run into thousands of dollars a day. That's one reason Worthington steam turbines are the first choice for driving blowers and compressors throughout the petrochemical industry.

But that's only *one* reason for a Worthington steam turbine drive. Take our Type S multi-stage steam turbine. It also gives you:

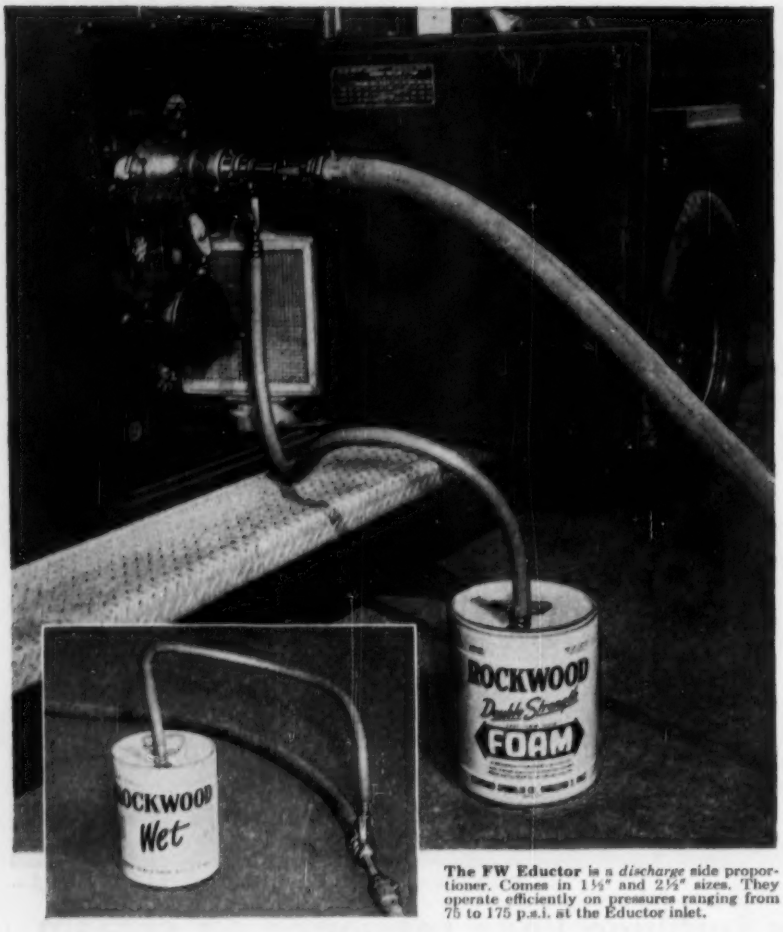
1. **Close speed regulation** — almost any constant speed or droop characteristic desired. A fact worth noting: Worthington is the only manufacturer offering as standard equipment the Woodward direct-acting governor, Woodward Oil Relay governor, Constant or Variable Speed Oil Relay governor or a mechanical shaft governor to best suit your conditions of service and for maximum economy.
2. **Remote control.** The Woodward Governor with pneumatic or hydraulic head allows remote control using air or other medium.
3. **Steam economy.** Every Worthington multi-stage turbine is designed to fit your specific service with lowest steam consumption.
4. **Low upkeep.** Sound design, accessibility of parts, perfect lubrication, assure continuous service with minimum maintenance.

Find out more about the Worthington steam turbines for your chemical or petrochemical applications. Write Worthington Corporation, Steam Turbine Division, Section T.5.4, Wellsville, N.Y. T54

WORTHINGTON

STEAM TURBINES

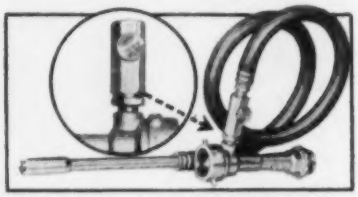
For more data on advertised products, use Readers' Service Cards, last page.



The FW Eductor is a *discharge* side proportioner. Comes in 1½" and 2½" sizes. They operate efficiently on pressures ranging from 75 to 175 p.s.i. at the Eductor inlet.

FFF Nozzle comes with Foam screen and solid Foam stream shaper.

Rockwood Eductors are designed for use with both the Rockwood FFF nozzle and the SG-60 nozzle with FF extension unit. SG-60 is an all-purpose nozzle that fights fires 5 ways — high velocity WaterFOG, low velocity WaterFOG (with applicator), FogFOAM, solid stream of water or of FOAM. FF extension unit discharges Rockwood FOAM in a solid stream or as FogFOAM, and covers large areas at one time.



The Variable FW Metering-Check Valve on the Rockwood Eductor is highly versatile, and is furnished with each FW Eductor. It incorporates both the Metering Valve and Ball Check Valve in one unit, and meters material into the hose line in any proportion from 1% through 6%.

One for the road!

Protect against flammable liquid fire due to tank truck accidents

With more traffic on congested highways, more filling stations, more and more gasoline tank trucks in daily service, *your* city is in greater danger of a flammable fuel fire than it has ever been before. A sudden crash of a tank truck passing through your city streets tomorrow could confront you with a difficult-to-control flammable liquid fire.

The use of Rockwood FW Eductor reduces the danger of disastrous losses due to such a fast-spreading fire. Developed for operation with Rockwood's FFF nozzle and SG-60 nozzle with FF extension unit, the FW Eductor introduces Rockwood regular FOAM, Double-Strength FOAM or WET (1% or 2%) into the hose line, quickly controlling and extinguishing flammable liquid and other fires.

Rockwood FW Eductor is the simplest form of proportioning you can buy. Ideal for municipal fire departments, oil refineries and industrial plants, it can be attached between discharge gate of a fire truck and hose line, or between hydrant and hose line, or between two lengths of hose.

Be prepared. Put this great fire fighter to work for you. Specify Rockwood FW Eductor when you order a fire truck.

Rockwood Double-Strength Foam Liquid, 3 parts mixed with 97 parts water, forms a solid FOAM blanket that quickly re-seals itself. Available in 5-gallon or 50-gallon drums.

Rockwood WET, 1 part mixed with 99 parts water, increases penetration and extinguishing action of water. Excellent for deep seated fires or where water is scarce. Can be used in proportions of 1% or 2% by volume for Class A and B fires. Available in 5-gallon cans or 50-gallon drums.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

PORTABLE FIRE PROTECTION DIVISION • 1086 Harlow Street, Worcester 5, Mass.

The **FOX Gas Processing Plant** was designed and constructed by Hudson in collaboration with Signal Oil and Gas Company. The plant design includes features reflecting a combination of the long experience of Signal in the operation of similar plants with the experience of Hudson in designing, constructing and initially operating more than 100 major projects for the oil and gas industry.

When additions now in progress are completed by Hudson, approximately 60 million cubic feet per day of casinghead gas from the Fox and nearby fields of Carter County, Oklahoma, will be processed, and about 3,000 barrels per day of finished products will be recovered from the gas.

Hudson is happy to add Signal Oil and Gas Company to its long list of clients, and particularly proud that through the coordinated efforts of Signal and Hudson this major project was completed in 7 months — from first discussion to smoothly operating plant.

DESIGNERS AND CONSTRUCTORS OF
OIL AND GAS PROCESSING PLANTS

HUDSON
ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

Depend on LADISH

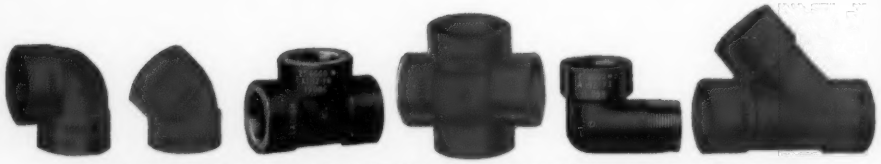
- Carbon Steels
- Carbon-Molybdenum Steels
- Chromium-Molybdenum Steels
- Nickel Steels
- Chromium-Nickel Steels
- Chromium-Silicon-Molybdenum
- Wrought Iron
- Chromium Type Stainless
- Chromium-Nickel Stainless
- Molybdenum Type Stainless
- Wrought Aluminum
- Aluminum-Copper Alloys

BUTT WELDING FITTINGS

½ inch through 42 inches . . .

FORGED CORROSION RESISTANT—LIGHT WEIGHT and A.S.A. FLANGES

½ inch through 24 inches . . .



FORGED SCREWED OR SOCKET WELDING FITTINGS and UNIONS

⅛ inch through 4 inches . . .

LARGE DIAMETER AND T.E.M.A.* STANDARD FLANGES up to 20 feet O.D.

*Tubular Exchanger Manufacturers Association

LONG WELDING NECKS

up to 24 inches, 150 lb. through 2500 lb.

Complete Service . . .

BUTT WELDING FITTINGS

Schedules 5S, 10S, 40S, 80S, and other Schedules and wall thickness.

FORGED CORROSION RESISTANT—LIGHT WEIGHT and A.S.A. FLANGES

150 lb. through 2500 lb. pressure ratings.

FORGED SCREWED OR SOCKET WELDING FITTINGS and UNIONS

150 lb. Corrosion Resistant and 2000 lb. through 6000 lb. ratings.

FOR FITTINGS FROM ANY FORGEABLE MATERIAL TO MEET YOUR SERVICE REQUIREMENTS

You get prompt, efficient service when you specify and order from the complete Ladish Controlled Quality line. Fittings *in any forgeable material* in virtually every type, size, wall thickness or pressure rating . . . are produced to one uncompromising Controlled Quality standard . . . and identified with heat code symbols pioneered by Ladish as verification of metallurgical integrity resulting from exhaustive tests made in the Ladish metallurgical laboratories.

For *complete service* on your fittings requirements, depend on the Ladish line and the services of your Authorized Ladish Distributor.

THE COMPLETE *Controlled Quality* FITTINGS LINE

LADISH CO.

CUDAHY, WISCONSIN

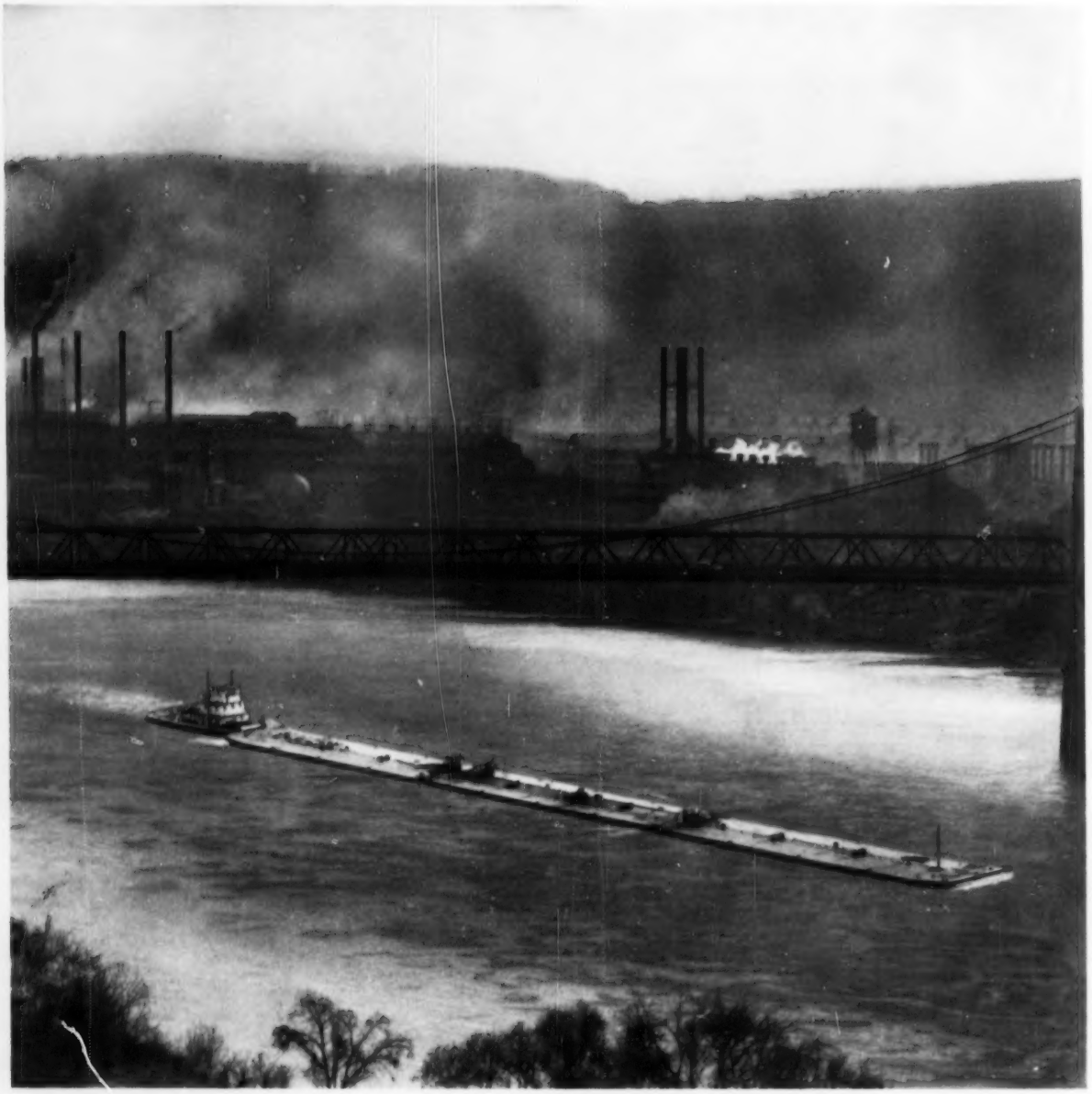
MILWAUKEE SUBURB

District Offices: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland
Chicago • St. Paul • St. Louis • Atlanta • Houston • Odessa • Tulsa
Los Angeles • San Francisco • Seattle • Havana • Mexico City • Brantford, Ont.

TO MARK PROGRESS

- Aluminum-Manganese Alloys
- Deoxidized Copper
- Hastelloy
- Titanium
- Forging Brass
- Everdur Bronze
- Silicon Bronze
- Manganese Bronze
- Wrought Nickel
- Nickel-Copper Alloys
- Inconel
- Monel

GOING PLACES *on the nation's rivers with Cities Service...*



Cities Service petroleum products travel by fast supertankers... they also move by plodding barge over the nation's inland waterways from Cities Service refineries to major midwest distribution centers... today they are traveling over water, over land and underground in record quantity, to meet a record customer demand.

CITIES SERVICE

A Growth Company

Number 14 of a series

top Cat on cracking efficiency!

Aerocat Triple A*

high alumina catalyst

balanced with HI PV*

Both high pore volume and high alumina content—that's what AEROCAT TRIPLE A High Alumina Catalyst offers refiners. This combination boosts cracking efficiency through

higher initial activity
higher thermal and steam stability
lower stack losses
excellent selectivity

In AEROCAT TRIPLE A High Alumina Catalyst, Cyanamid has carefully balanced high pore volume with pore diameter and specific surface. The result is higher activity maintenance than is possible with low pore diameter high alumina catalysts.

AEROCAT TRIPLE A is the product of a 7-year research program at Cyanamid. Commercial experience in 24 units has yielded precise determinations of its cracking efficiency and product distribution in equilibrium. It's a proved and tested catalyst!

Your Cyanamid representative will be glad to tell you what AEROCAT TRIPLE A High Alumina Catalyst with HI PV can do for your operation. Call him today.

*Trade-mark

AMERICAN Cyanamid COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza • New York 20, N.Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal

For more data on advertised products, use Readers' Service Cards, last page.

Here is EXTRA MOTOR VALUE

Double-shielded bearing
Large grease reservoirs
Bolted-on bearing cap
Labyrinth seals

This Allis-Chalmers Bearing Design Gives More for Your Motor Dollar

You can lubricate these bearings without dismantling the motor. Pipe-tapped holes in the bearing housings at two points provide means for inserting new grease, flushing out old grease and relieving pressure during re-greasing.

The bearing cap is held tightly in place against the inner face of the bearing enclosure. This cap, with its close running clearances, minimizes the possibility of grease entering the interior of the motor . . . retains an ample supply within the bearing enclosure.

At the outer side of the bearing, double labyrinth seals keep grease in, also keep dirt out. What's more, large grease reservoirs act as additional dirt barriers.

Look for the extra bolts on the end housing . . . the sign of greater value. Ask your Allis-Chalmers representative or Authorized Distributor to give you the facts on this maintenance-saving design. Or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B7286. A-4855

ALLIS-CHALMERS

HOW TO GET THE BEST RESULTS FROM ANY TRAPPING JOB...

DRAINING CONDENSATE FROM STEAM

How to correctly size, install and maintain steam traps for any pressure, any temperature, any load... Armstrong inverted bucket trap design principles and advantages... sizes, list prices, physical data, capacities... data on variable loads, warming-up loads, submerged coil heat transfer, steam main and riser drainage... trapping of unit heaters... power plant trapping, and many other subjects. ASK FOR 44-PAGE CATALOG J, The Armstrong Steam Trap Book.

DRAINING LIQUIDS FROM AIR AND GAS

How to select and install ball float traps for draining light liquids or water from drip points, aftercoolers, separators, etc., in compressed gas and air systems... liquid level control hookups... high pressure trapping to 1000 psig... trap materials for corrosive service... capacities, physical data, list prices, single lever, compound lever and "snap-action" traps. ASK FOR BULLETIN 289.

VENTING AIR AND GAS FROM LIQUIDS

Selection and installation of ball float traps for venting air and gas from water and light liquids under pressure... contains useful table on air discharge through various size orifices at pressures from 1 to 1000 lbs.... when and how to back vent traps... floats and mechanisms for other manufacturer's devices... sizes, list prices, materials, dimensional data for Armstrong Ball Float AR Traps. ASK FOR BULLETIN 450.

DRAINING WATER FROM LIGHT LIQUIDS

Dual gravity trap selection and installation explained and diagramed... for draining gasoline separators, dehydrator tanks, debutanizers, etc.... orifice capacity data, dimensions, materials, list prices for Armstrong Ball Float D/G Traps. ASK FOR BULLETIN 2091.

Free on request without obligation—call your local Armstrong Representative, or write Armstrong Machine Works, 852 Maple Street, Three Rivers, Michigan

ARMSTRONG

INVERTED BUCKET and BALL FLOAT TRAPS FOR THE PETROLEUM INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

Retubing? Rely on

keep Heat

First for Lasting Quality—from Mine to Market!

Phelps Dodge COPPER-BASE ALLOY Tubes to

your Exchangers On-Stream!

- ✓ **Complete line of copper-base alloys** including Bi-Metal combinations to meet special corrosive conditions.
- ✓ **Speedy delivery** from strategically-located warehouses.
- ✓ **Careful analysis of your corrosion problems** by experienced engineering staff.
- ✓ **Quality-controlled fabrication** to assure finest tube properties.
- ✓ **Information and sales service** available from nearest Phelps Dodge district office.*

PHELPS DODGE COPPER PRODUCTS CORPORATION

*SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle Washington, D. C.

WHAT'S NEWS AT BRISTOL . . .

FIRST instrument system that carries out BASIC–GRAPHIC PANEL idea completely!

A WIDE SELECTION: For example, there are 35 receiver and 34 controller models and the widest variety of transmitters on the market. A model can be found among these that will exactly meet any requirement.

FULL PLUG-IN SERVICE: Change recorder to an indicator or vice versa in 10 seconds with ABSOLUTELY NO INTERRUPTION WHATSOEVER TO AUTOMATIC CONTROL.

Pull complete chassis out (one-piece chassis – no tools required). With chassis removed you get the same automatic control as before.

Change from one model to another or if trouble is suspected in a plug-in unit, the doubtful unit can be replaced by a spare while the suspected unit is checked in the service shop – out-of-service time is thus eliminated.

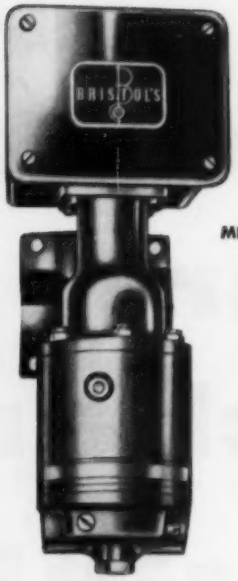
CONTINUOUS VALVE POSITION INDICATION on *same instrument scale as set point scale,* gives continuous data on control valve position – makes "bumpless" transfer possible simply by matching pointer positions – no need to read actual scale values – minimizes reading errors – speeds operations.

SCALES ARE SCIENTIFICALLY DESIGNED for instant, error-free readability – a new degree of close-up, as well as distance readability.

Write today for more details. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 5.14

METAGRAPHIC INSTRUMENTS MEASURE, RECORD, INDICATE, AND AUTOMATICALLY CONTROL

Pressure • Vacuum • Absolute Pressure
Differential Pressure • Liquid Level • Flow
Temperature and • Mechanical Motion



1

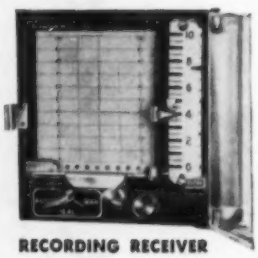
METAGRAPHIC TRANSMITTER

SUPPLIED IN A VERY WIDE VARIETY OF SPANS AND RANGES: For example, absolute pressure instruments are made in ranges as low as 5mm mercury absolute. Pressure instruments as low as 5 inches water to 10,000 psi. Over-range protection available up to 400% over-range.

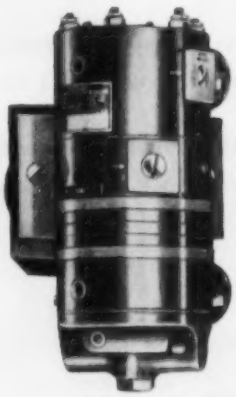
2

NO INTERRUPTION WHATEVER TO AUTOMATIC CONTROL when receiver chassis is removed.

OFFERED FOR UP TO THREE MEASURED VARIABLES – with air pressure regulators or air loaded regulators – three-position manual-automatic transfer valves for automatic control and *six-position (on the same knob) transfer valves for cascaded control.*



RECORDING RECEIVER



CONTROLLER

3

VARIETY AND FLEXIBILITY: The most flexible and complete line of controllers offered – 34 different models.

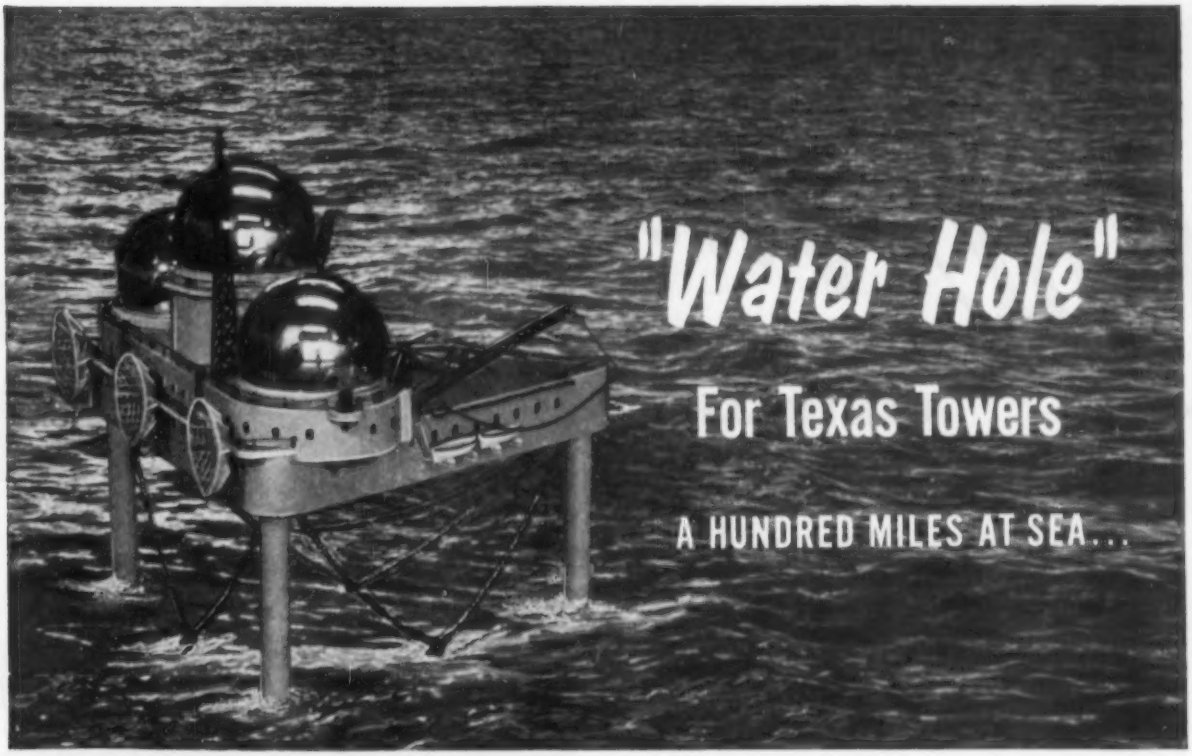
PLUG-IN FLEXIBILITY: Controllers are designed for full plug-in interchangeability for change of control mode or service. This means no process down-time for maintenance – no off-specifications product.

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

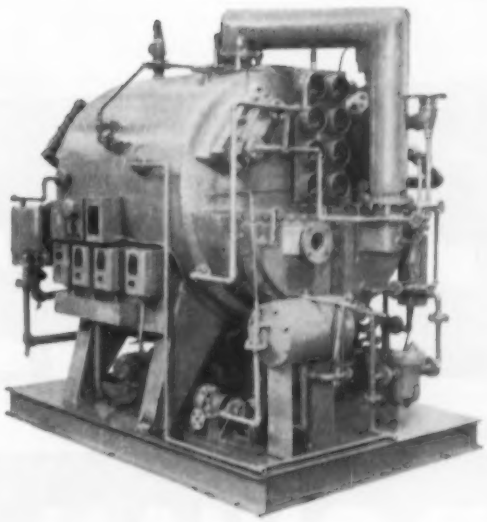
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



Early-warning radar stations, standing far out in the open ocean, need plenty of fresh water—for drinking as well as other purposes. And to supply it, they depend largely upon sea water evaporators using Bridgeport condenser tubes.

In these installations Bridgeport 90-10 Cupro Nickel Tube was chosen because of its excellent service in evaporators handling sea water. Its resistance to general impingement corrosion at high velocities often offers unique advantages over other alloys in many applications.

This is but one of many effective applications of a particular Bridgeport Condenser Tube Alloy —carefully selected to give optimum performance on a specific job. Bridgeport's Technical Service will be glad to help you select from a wide range of Bridgeport alloys the one tube best suited to your particular operating conditions. Call your nearest Bridgeport Sales Office for complete information.



Pure, fresh drinking water for "Texas Towers" is distilled from the sea by a Cleaver-Brooks Sea Water Evaporator equipped with Bridgeport Cupro Nickel Condenser Tubes.

BRIDGEPORT BRASS

Offices in Principal Cities • Conveniently Located Warehouses

Bridgeport Brass Company, Bridgeport 2, Connecticut
In Canada: Noranda Copper and Brass Limited, Montreal

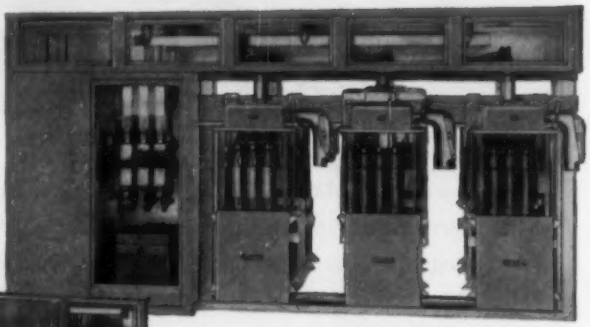
BRASS Bridgeport CO.

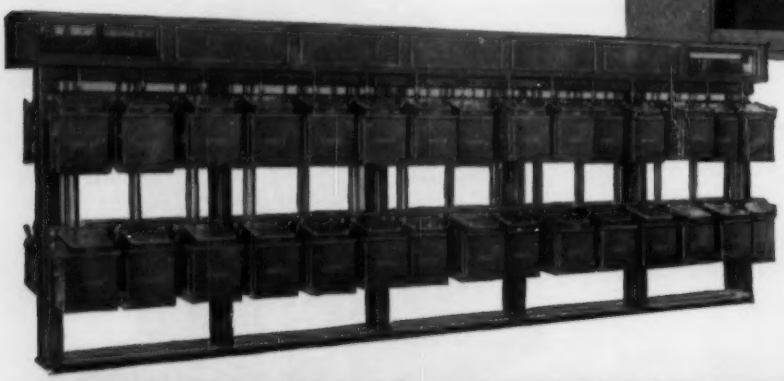
For more data on advertised products, use Readers' Service Cards, last page.

Oil Immersed

LOW VOLTAGE CENTRALIZED CONTROL

Rowan Low Voltage Centralized Control units are designed to meet modern industry's increasing demand for greater centralization of motor control. They consist of bus compartment, bus mounted on porcelain insulators providing liberal spacing, necessary motor starting equipment, auxiliary and pilot devices. Individual control transformers may be installed either in the bus compartment or in the starter. These units are designed for indoor or outdoor service . . . unique construction eliminates the use of gaskets for outdoor service.





ABOVE—Closed view and open view of a Centralized Control unit showing Disconnect Switches with incoming line circuit breaker for an outdoor application.

LEFT—Closed view of a Centralized Control unit showing Frames 50 and 100, 780-KBF Starters, mounted on a sturdy steel structure.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

THESE ADDITIVES ARE NOT ON THE PUMP BUT THEY TOO MEAN "PERFORMANCE"

Tenamene

EASTMAN GASOLINE ADDITIVES

Though unidentified at the point of final delivery, the presence of these additives is vital to the dependable performance of gasoline. For help in the careful selection and economical use of these gum-inhibiting additives, call on Eastman's highly qualified petroleum specialists.

For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to Eastman Chemical Products, Inc., Kingsport, Tennessee—a subsidiary of Eastman Kodak Company.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; New York—260 Madison Ave.; Framingham, Mass.—65 Concord St.; Cincinnati—Carew Tower; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth St.; Salt Lake City—73 S. Main St.; Seattle—821 Second Ave.

For more data on advertised products, use Readers' Service Cards, last page.

YOUR NAME HERE*.....

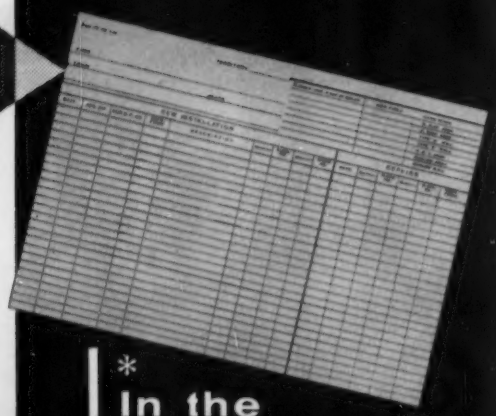
may save you time and money ...keeps production UP

When industrial furnace enclosure repairs become necessary today, there's a lot of satisfaction in knowing that they can be made efficiently—and quickly—under the supervision of the company which designed those enclosures.

If you are fortunate enough to have Bigelow-Liptak furnace enclosures in your plant—the entire record of the installation; its description and lists of all repair parts are at the finger tips of our production department—ready to be used at a moment's call to help you get your furnace back in efficient operation in a minimum of time.

Experiences like the recent predicament of one of the major oil refineries prove the value of this Bigelow-Liptak feature. By means of comprehensive Trade Cards—that cover every Bigelow-Liptak installation from one end of the world to the other—recommendations were made over the telephone to this refinery which was having difficulties because war production during the last several years had forced operation to almost double its designed capacity. Necessary repair parts were indicated. A fully informed engineer was rushed to the job. And this aviation gasoline plant which had operated five years without repairs was back in service in four days at this greatly increased rating.

"Please accept our appreciation for the effort made to put this plant back in operation. It is nice to know we are dealing with companies and individuals who feel an interest and a responsibility in the jobs they have furnished," wrote the chief engineer of this great refinery. This is but one of dozens of recent tributes paid to the cooperation, engineering skill and efficient organization of Bigelow-Liptak. Your operation may depend not only on the design of the heat enclosure but the cooperation and efficient organization that backs it up.



* In the general office of Bigelow-Liptak

. . . there is a Trade Card that contains a detailed record of every installation. On this card will be found all of the data and information necessary and useful in servicing the job. Many of these cards are never referred to because Bigelow-Liptak enclosures are designed for long dependable service. But since furnace enclosures are the parts most subject to wear and tear, these records often become life savers for our customers.

When emergencies come we can quickly refer to any customer's Trade Card and find an accurate record of any installation. In a few minutes, with the aid of this information, we can set in motion the work that will enable him to get his furnace back in service in a minimum time. Your name on a Bigelow-Liptak Trade Card may save you money and invaluable time.

It will pay you to discuss your heat enclosure problem with Bigelow-Liptak—if you want enclosures that will give service and economy over a long continuous operating period. Get in touch with a Bigelow-Liptak engineer.

BIGELOW-LIPTAK *Corporation*

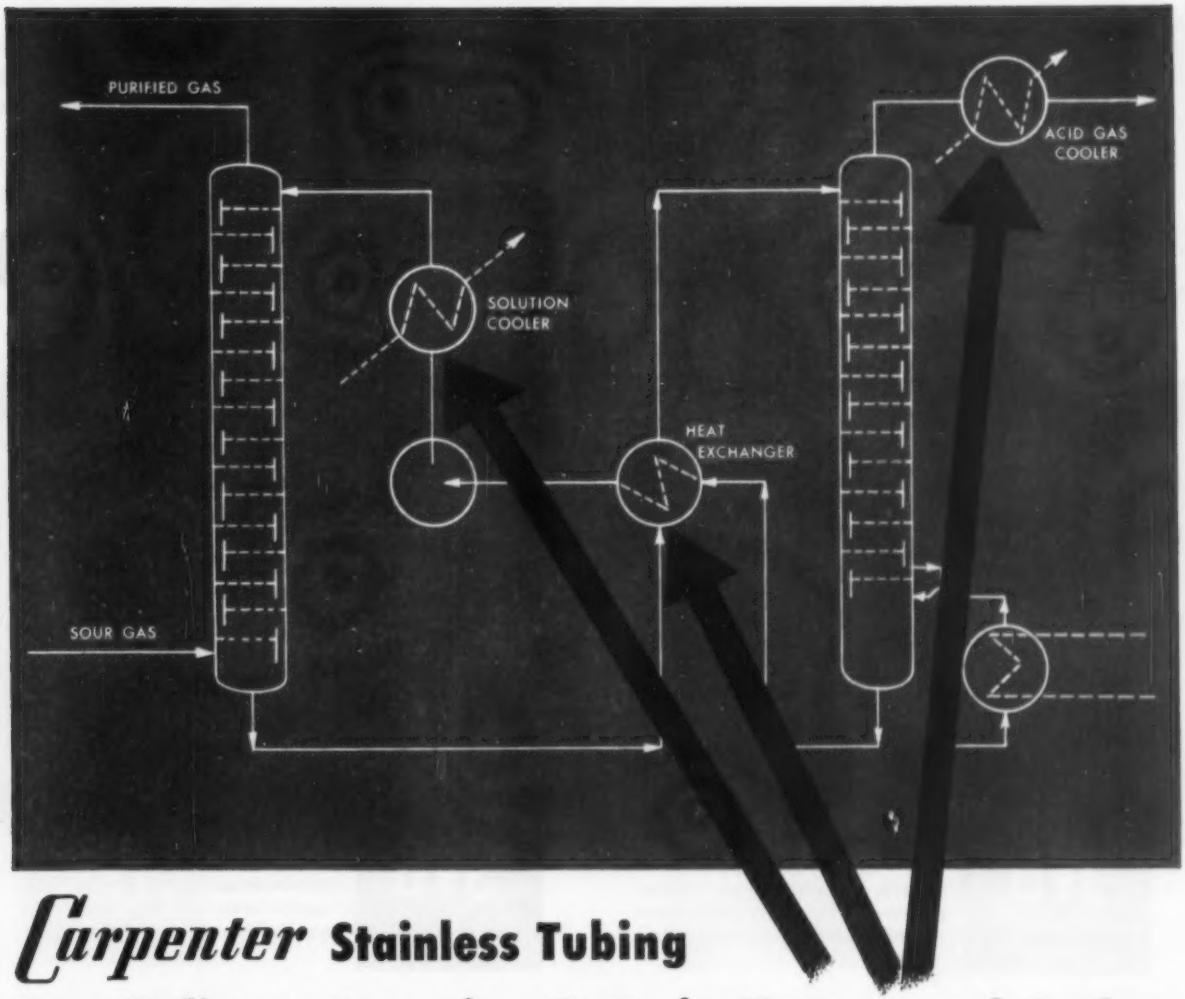
AND BIGELOW-LIPTAK EXPORT CORPORATION
2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*

ATLANTA • BOSTON • BUFFALO • CHICAGO • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MIAMI • MINNEAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TULSA • MONTREAL • SAULT STE. MARIE, ONT. • VANCOUVER • WINNIPEG

For more data on advertised products, use Readers' Service Cards, last page.



Carpenter Stainless Tubing

Cuts Refinery Corrosion Costs in Heaters and Coolers

This diagram shows where Carpenter Stainless Tubing has cut corrosion control costs and reduced down-time in refinery equipment used for removal and recovery of *hydrogen sulfide* from gases.

By re-tubing the solution heater and cooler and the acid gas cooler with Carpenter Stainless Tubing, tube life in these units already has been more than doubled. The Carpenter tubing has been in service more than 5 years and is still going strong. In other modern refinery processes, too, re-tubing with Carpenter Stainless Tubing is paying off in lower maintenance costs and increased plant operating efficiency.

Why not apply the cost-cutting, time-saving advantages of Carpenter Stainless Tubing to your operations to get greater freedom from costly corrosion troubles? Ask your local Carpenter Representative or write for information about the new kind of Carpenter Stainless Tubing now available for refinery services.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

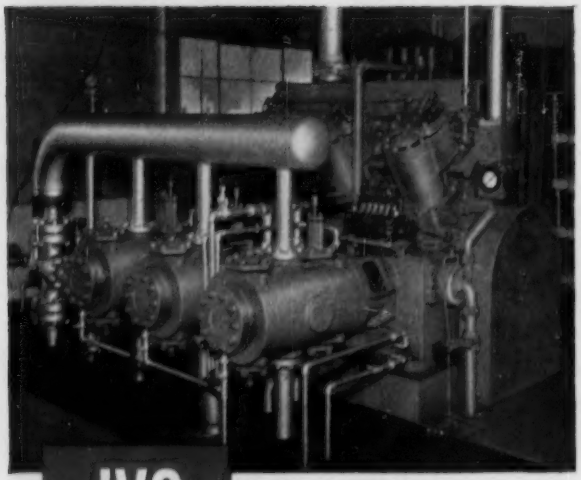
Here's a helpful guide for selecting standard and special analyses of stainless tubing and pipe for best results in corrosive services. Ask for Bulletin T. D. 113.

Carpenter

Stainless Tubing & Pipe

For more data on advertised products, use Readers' Service Cards, last page.

Be sure your gas-engine compressor has these two



JVG
110 to 220 hp

Ingersoll-Rand JVG gas-engine compressor installed on a natural gas pipe line for recompression from 350 psi intake to 410 psi discharge.

SVG
330 to 660 hp

Bank of five I-R gas-engine compressors in gas booster service. SVG unit in foreground compresses natural gas from 47 to 400 psi.

From 110 to 2000 hp, these I-R units have two advantages that set them apart from all others!

A gas-engine compressor is really *two* machines in one. A gas engine to provide the *power* and a compressor to do the *work*. In each of these equally important functions, Ingersoll-Rand has, over the years, pioneered and perfected basic types of construction that are common to their entire line of gas-engine compressors.

1. *Four-cycle Flexibility*

Every I-R unit utilizes a V-type *four-cycle* engine. That's because only the four-cycle engine assures stable and dependable operation over the widest range of speeds and loads. It delivers smooth power all the way from half speed to full speed and from no load to full load, or any combination within this range. In many applications this four-cycle flexibility of loading is a vital necessity to meet the load swings and speed variations that are a part of normal operation.

Even where speeds and loads are fairly constant under normal conditions, the four-cycle engine provides a valuable margin of safety to take care of unexpected or emergency fluctuations in speed and load without danger of stalling out.

2. *Compressor cylinders engineered to the job . . . using valves from the most complete line available.*

Every I-R gas-engine compressor uses compressor cylinders and valves that are tailored to meet the

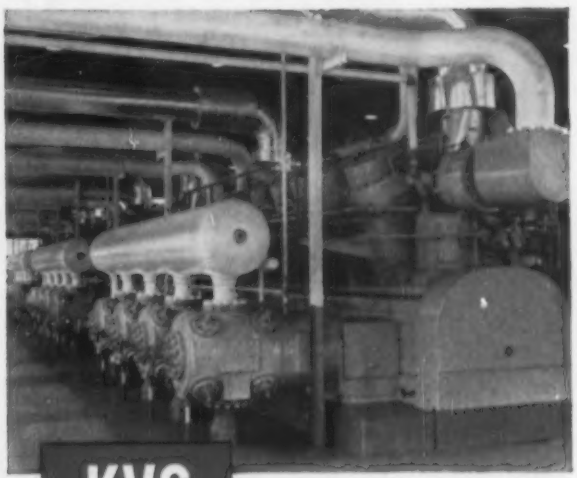
COMPRESSORS • CONDENSERS • AIR & ELECTRIC TOOLS

engine compressors outstanding features

KVG

380 to 1,320 hp

Six Ingersoll-Rand KVG gas-engine-driven compressors installed on a large Southwestern transmission line.



KVS

2,000 hp

Four of seven Type KVS turbo-charged gas-engine compressors installed in a large gasoline plant. Each unit compresses process gas from 0 to 800 psi.

precise requirements for each application. Their world-wide reputation for lasting dependability and reduced maintenance is the result of more than 77 years of specialized experience in designing and building air and gas compressors.

Ingersoll-Rand valves are the most dependable available. Complete records from many pipeline compressor stations show that I-R valves run for many months without forcing a compressor shutdown. And Ingersoll-Rand has valves to cover the entire range of operating requirements for any pressure, any type of gas . . . more types and sizes of compressor valves than any other manufacturer.

These two basic advantages . . . four-cycle flexibility and the extra dependability of job-engineered I-R compressor cylinders and valves . . . add up to long-range savings in operating and maintenance costs.

Your nearest Ingersoll-Rand representative will be glad to give you all the facts on any type of unit. His wide experience in the selection, application and installation of this equipment can save you time and expense all along the line.

Ingersoll-Rand

6-262 ♥ 11 Broadway, New York 4, N. Y.

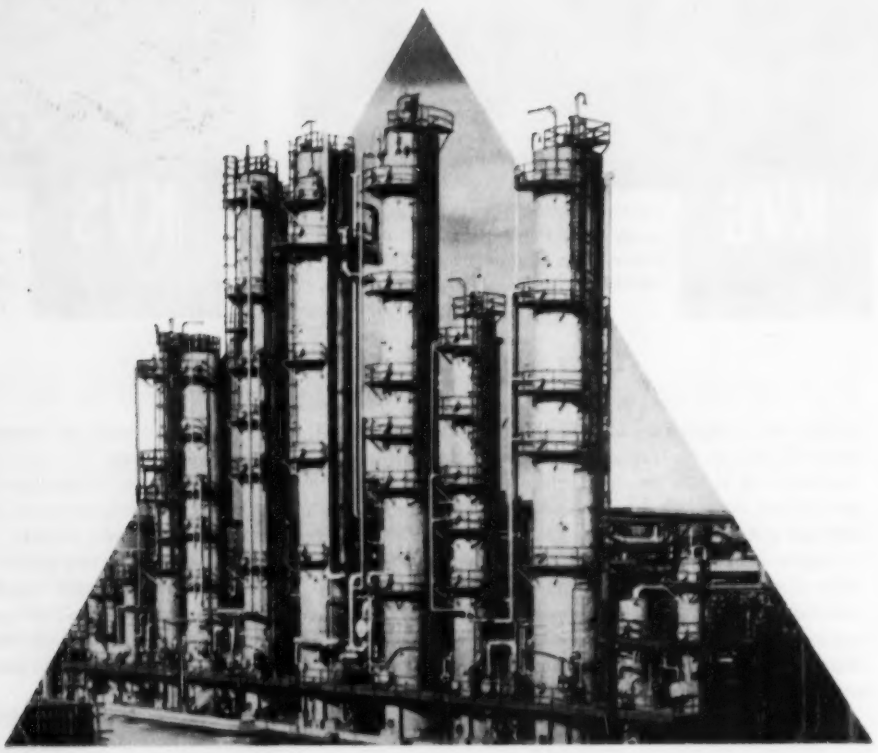
4-CYCLE

PUMPS • **ROCK DRILLS** • **GAS & DIESEL ENGINES**

For more data on advertised products, use Readers' Service Cards, last page.

Experienced in Plant and Unit Design from Crude to Finished Product

Conversion
Separation
Purification



Name the separation step and we can match it up with direct or parallel experience. Distillation, Liquid Extraction, Absorption, Crystallization are typical of the operations which our engineers know thoroughly and for which they have designed many a plant and unit.

BADGER MANUFACTURING COMPANY

230 BENT STREET, CAMBRIDGE 41, MASS. • 60 EAST 42nd STREET, NEW YORK 17, N.Y.

"MEETING ROOM" . . .

rent free!

Forty-three American railroads own P-A-X "inside" telephone systems. These railroads *encourage* employees to use the telephone for exchanging information and instructions; they find that operations are thus speeded up—confusion, delays and errors are held to a minimum. P-A-X telephones on desks, in shops, and at trackside booths provide convenient "meeting rooms" for swift transacting of railroad business!

Because P-A-X is railroad-owned, these calls are made without charge. There is no need to limit the number or length of calls. And of course, telephone installations and moves are made by railroad personnel *when and as desired*, and maintenance is easily handled by regular communication and/or signal crews.

Let us tell you which railroads own P-A-X's, and how they use them for maximum operating efficiency. Call or write Automatic Electric Sales Corporation (HAymarket 1-4300), 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

ORIGINATORS OF THE AUTOMATIC TELEPHONE

DUAL METAL... answer to

What is it ?

To thirty-one of America's largest industries with problems of abrasion or corrosion—or both—"Dual Metal" means U. S. Pipe's Special Products Division.

Specifically, "Dual Metal" is our name for centrifugally cast cylindrical sections in which two dissimilar metals are bonded metallurgically by centrifugal force and temperature.

"Dual Metal" centrifugally cast, integrally fused combinations of two dissimilar metals are doing industry's most difficult and exacting jobs better and more economically than ever before.

Design engineers have been quick to recognize the outstanding merits of a process capable of combining the desired mechanical and chemical properties no single metal possesses.

"Dual Metal" means versatility, efficiency and economy.

Research and development play a vital and important role in the centrifugal casting of "Dual Metal" combinations. Our Pilot Foundry is devoted entirely to process and product improvement.

UNITED STATES PIPE & FOUNDRY CO.

Special Products Division

SPECIAL PRODUCTS DIVISION U S P

BURLINGTON, NEW JERSEY

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, CLEVELAND, DETROIT, PITTSBURGH, HARTFORD, BURLINGTON

your TURNAROUND problems

"Dual Metal" solves one of the petroleum industry's most severe and costly problems—catalyst erosion of lift pipe and catalyst handling lines.

In making a "Dual Metal" lift pipe the outer shell of weldable alloy steel is poured into a rapidly rotating mold. The abrasion-resistant alloy iron core is introduced at the proper time and temperature. Result? A metallurgically bonded two-metal structure that combines the strength and weldability of low alloy steel and the superior abrasion resistance of alloy iron.

"Dual Metal" lift pipes are now in use in over 60 of the nation's leading refineries. In one typical refinery periodic examinations of high temperature catalyst pipes have indicated abrasion resistance of better than 16 to 1 over conventional steel piping. A once-troublesome bottleneck in processing has been eliminated and turnaround operations made shorter—a major saving of both time and money.

Perhaps this versatile process is the answer to your particular problem. Write today for specific literature and information on "Dual Metal's" applications for the refining industry.

"DUAL METAL" CENTRIFUGAL CASTINGS: SIZE RANGES

OUTSIDE DIAMETER: 6" to 36" **WALL THICKNESS:** ½" and up
LENGTH: Up to 14 ft. without welding
TYPICAL OIL INDUSTRY APPLICATIONS: Catalyst Lift Pipe, Depressurizing Pipe, Catalyst Transfer Lines, Slush Pump Liners, Valve Nozzles, Extrusion Liners, etc.

Left. *Cross-section view of dual metal piping consisting of a weldable SAE 4120 steel outer shell and a metallurgically bonded inner layer of high carbon-high chromium abrasion resisting iron. Photograph actual size. Composition of the hard inner layer:*

C	Mn	P	S	Si	Cr
2.85	1.10	.009	.023	.85	29.36

Below. *Photomicrograph showing the bond or fusion zone between the outer and inner metals. The mild etch required for the 4120 steel did not attack the high chromium iron. Etched—100 diameters magnification.*

STAYNEW FILTERS' DOUBLE ACTION

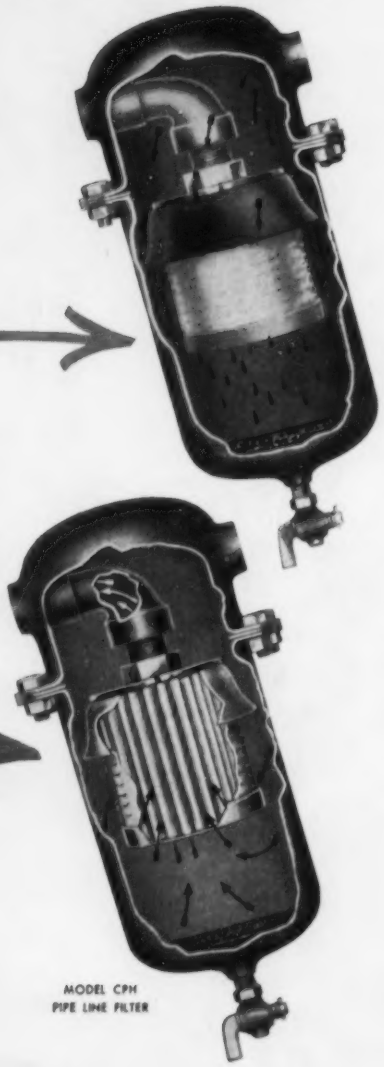
Guards Against Water, Oil and Pipe Scale

MECHANICAL SEPARATION

1. Deflector cup directs flow of air or gas together with water, oil and dirt to the walls of the housing and then downward at high velocity into the base where liquid and heavier dirt particles are deposited.

FILTRATION

2. Air or gas, having been mechanically cleaned, rises at low velocity through the Radial Finned Filtering element or insert which removes the lighter air-borne material.



MODEL CPH
PIPE LINE FILTER

This exclusive Double-Action principle of Staynew Pipe Line Filters assures sustained, trouble-free operation. Inexpensive, quickly installed and easily maintained, these filters keep air operated or controlled equipment free from pipe scale, dust, dirt, and condensate. Wherever you require air and other gases *clean* and *dry*—demand and get—Staynew Pipe Line Filters.

Write today for complete Staynew Pipe Line Filter Bulletin B-1A.

Representatives in Principal Cities

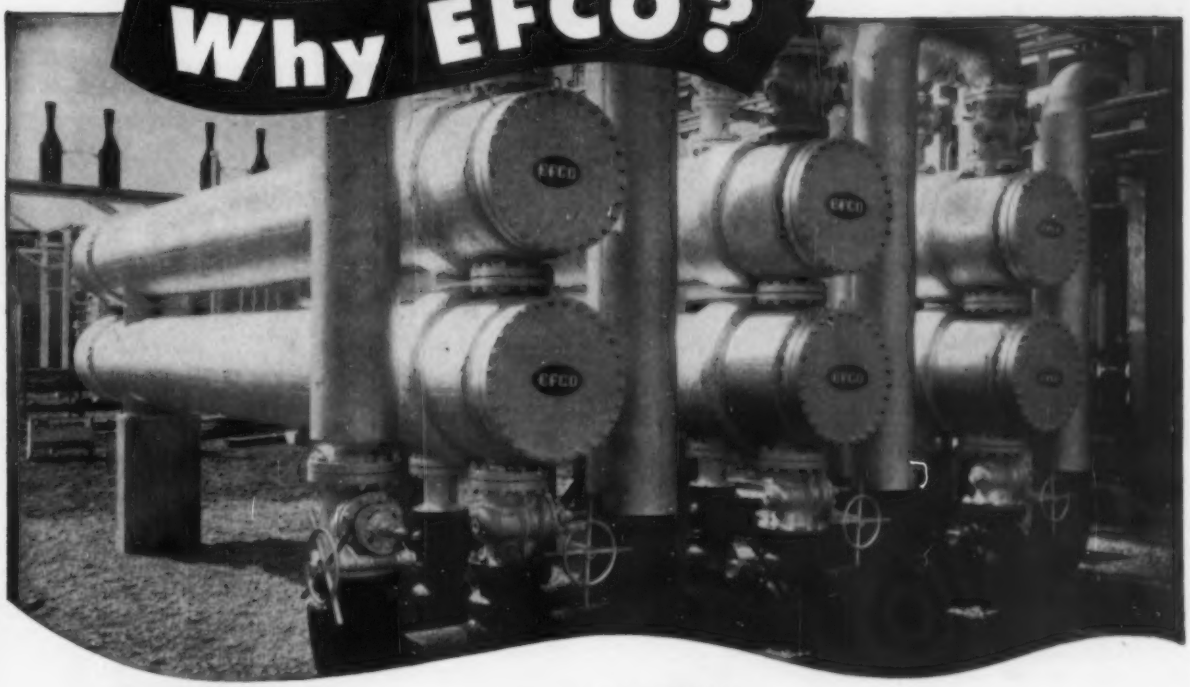
DOLLINGER OIL PROTECTOMOTOR AND STAYNEW FILTERS

DOLLINGER CORPORATION

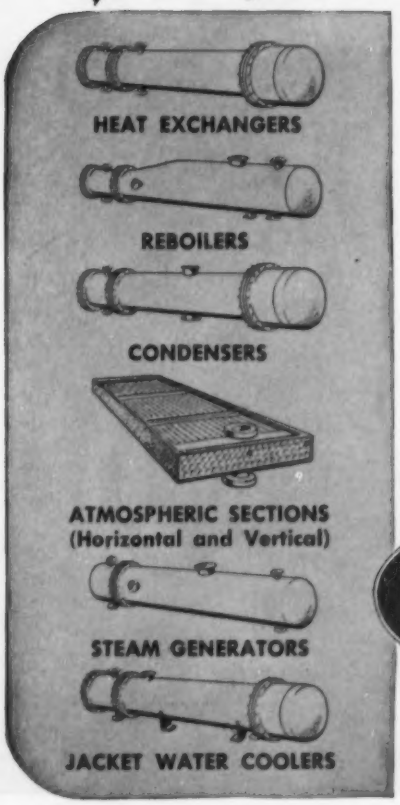
47 Centre Pk., Rochester 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

Why EFCO?



Performance
is the answer!

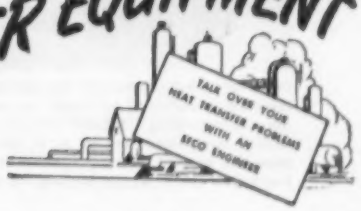


With the installation of EFCO heat transfer units in your plant, you will be sure of getting *guaranteed performance* with the extra advantages of low maintenance cost, high operating efficiency, long life and freedom from leaks.

Talk over your heat transfer problems with an EFCO engineer. He will tell you about EFCO installations that have successfully solved problems similar to yours and explain how EFCO equipment will give you the performance you want.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

EFCO
HEAT TRANSFER EQUIPMENT



For more data on advertised products, use Readers' Service Cards, last page.

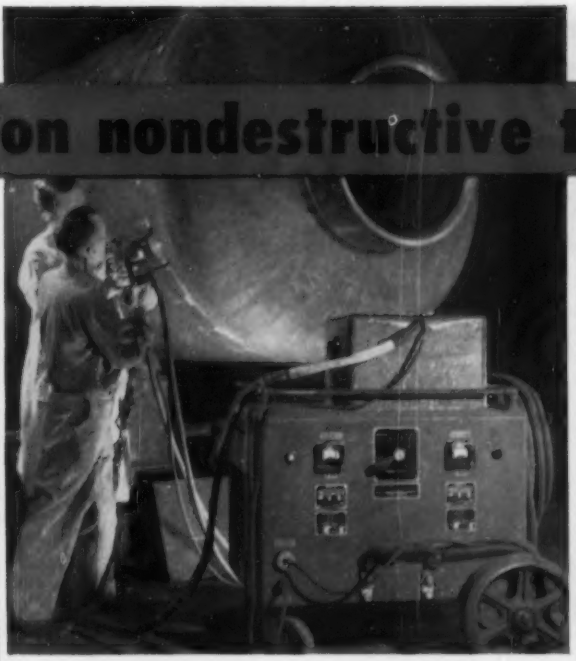
A. O. Smith reports

Radiography is perhaps the most important inspection method A. O. Smith uses to detect flaws in welds and adjacent plate material. The products of A. O. Smith — ranging from critical ordinance and atomic energy equipment to pressure vessels and heat exchangers—require radiographic inspection of light gauge thickness and heavy wall thicknesses exceeding 6 inches. We make use of both x-ray and gamma-ray inspection and both methods record on film the density variables characteristic of unsound material. Technician is shown x-raying the longitudinal seam of an alloy-lined shell.

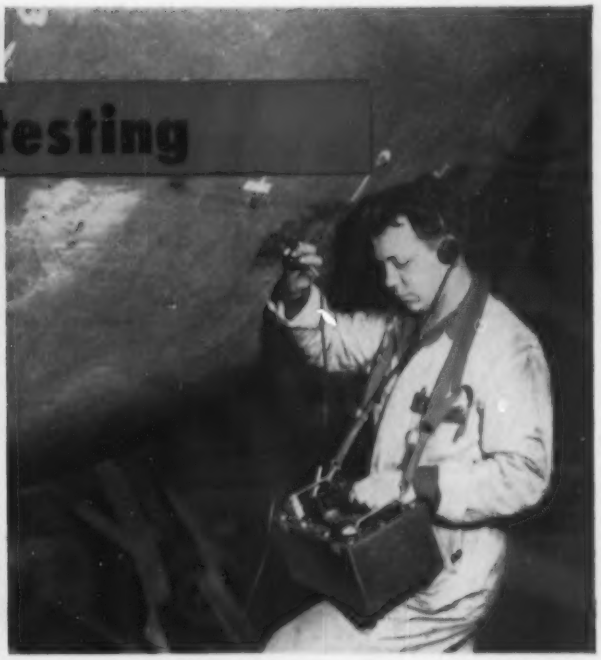
Skilled interpretation of the film is, of course, the key to successful radiographic inspection. If all the film developed and interpreted at A. O. Smith since 1932 were laid end to end, the strip would extend over 1,224 miles.

Important applications for nondestructive tests are those that determine acceptability of materials for specific corrosion-resistant or welding characteristics. Sulphur printing, illustrated here, is one of the control inspections used by A. O. Smith. The test is designed to determine the amount and segregation of sulphur present in forgings. This inspection evaluates the forging for welding.

on nondestructive testing



Still another method of flaw detection used by A. O. Smith is the magnetic particle test. Magnetic particle tests are ideal for detecting surface and sub-surface faults in ferrous materials. In this picture, technicians are shown inspecting the welds on a pressure vessel.



Ultrasonic testing (inspection utilizing high-speed sound waves) is another method A. O. Smith uses for quality control of heavy sections. The picture shows an additional application of ultrasonic testing — operator is determining wall thickness of 167,000-lb. vessel.

Nondestructive inspection is one more reason for the dependability of A. O. Smith vessels, exchangers and other process equipment.

The man in charge of A. O. Smith's nondestructive testing . . .

A. Cota. With A. O. Smith for more than 27 years, Mr. Cota has specialized in nondestructive testing since 1932. He has been a leading force in the development of many of the techniques and procedures now used throughout industry. He is past-president of the National Society for Nondestructive Testing . . . is serving on nondestructive testing committees of ASME and ASTM and in various other control groups. This experience is another reason why it's wise to call A. O. Smith first for processing equipment.

Illustrated here are just a few of the nondestructive testing processes by which A. O. Smith maintains the quality of its products. Of course, there are many other tests, too — both nondestructive and destructive — all designed to help create equipment that will excel in your operations.

A. O. Smith was one of the members of the original committee that first established radiographic inspection techniques and standards. Also, we have used magnetic particle testing since 1934 . . . ultrasonic testing procedures since 1945.

Through research . . . a better way

A.O.Smith

CORPORATION

PROCESS EQUIPMENT DIVISION

HEAT EXCHANGERS • PRESSURE VESSELS

Milwaukee 1, Wisconsin

International Division: Milwaukee 1, Wisconsin

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EAGLE-PICHER

SUPER "66"

INSULATING CEMENT

→ *STICKS* to hot or cold surfaces ←

BECAUSE IT STICKS, *it saves time*! Eagle-Picher Super "66" *really sticks*, makes difficult jobs easy, usually requires no reinforcing on applications up to 1½ inches thick. It applies quickly to any equipment, cold or heated up to 1800 F.

BECAUSE IT STICKS, *it saves money*! Low-cost Super "66" provides far greater coverage and more effective insulation. Its "springy ball" structure of small, resilient pellets of mineral wool, with thousands of dead air cells, assures maximum fuel savings!

BECAUSE IT STICKS, Eagle-Picher Super "66" can be used on irregular shapes where application of other insulations is often impossible.

PREVENTS RUST, TOO! Super "66" contains a special rust inhibitive that actually prevents corrosion.

WRITE FOR FREE SAMPLE TODAY!

Prove to yourself how easy it is to apply Super "66" wherever insulation is needed!

Since 1843

EAGLE EP PICHER

THE EAGLE-PICHER COMPANY

Producing a complete line of industrial insulations

Cincinnati 1, Ohio

(Member of Industrial Mineral Fiber Institute)

(Conforms to Commercial Standard CS117)

There's a faster, safer, cheaper, more accurate way to measure tanks with... a new

Gilbarco

ELECTRONIC TANK GAUGE

A crew of hand gaugers can climb slippery steel stairways in icy cold to lower tapes through opened manholes. Or one man can sit in a gauge house before a Gilbarco Remote Receiver and gauge tanks at the rate of fifty an hour—with a degree of accuracy never approached by *any* other method. Here is *automation* in tank gauging. For illustrated booklets and full information about this great new advance in liquid level measurement, write . . .

GILBERT & BARKER MANUFACTURING COMPANY, WEST SPRINGFIELD, MASSACHUSETTS

For more data on advertised products, use Readers' Service Cards, last page.

PLASTIC

VALVES and PIPE FITTINGS

by

WALWORTH

These new corrosion-resistant valves and pipe fittings are molded of rigid polyvinyl chloride. They round out complete lines of Walworth Valves and Fittings of Steel, Stainless Steel, Bronze, Iron, and Special Alloys. A brochure explaining the complete Walworth PVC product story has been prepared for your information. Just send us your name and address. *Walworth Company, General Offices, 60 East 42nd Street, New York 17, New York.*

THE NEW **CHIKSAN**

Hydraulically Controlled

MARINE LOADING ARM

The first basic improvement for loading and unloading of petroleum products in over 30 years.

- Speeds tanker turn-around-time
- Far less manpower to operate
- Long life, trouble free operation
- Elimination of hose bursts
- Lowers fire and work compensation premiums
- Operates from −60°F. to +225°F.
- One motor, one switch controls operation
- Static and spark resistant
- No manhandling of hose

CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

fmc

CHIKSAN COMPANY; Brea, California

Please send me more information on the Chiksan Marine Loading Arm.

Name_____

Company_____

Address_____

City_____ Zone___ State_____

511

CHIKSAN

CHIKSAN COMPANY — BREA, CALIFORNIA • CHICAGO 3, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas · Subsidiaries: Chiksan Export Co., Brea, Calif., Newark 2, N. J. · Chiksan of Canada, Ltd., Edmonton, Alta

Fittings stay fastened in Corrosive Acid Spray

PROBLEM:

Selecting fastenings that would hold pipe fittings together in a unit that is constantly subjected to a hot sulphuric acid spray. Bolts were formerly falling apart in four months' time.

REMEDY:

Use of nuts and bolts made of wrought HASTELLOY alloy C.

RESULT:

Fastenings made of HASTELLOY alloy C are still holding many months after ordinary bolts had to be replaced.

HASTELLOY alloy C is the most universally corrosion-resistant alloy available today. In addition to aerated sulphuric acid, it has excellent resistance to such strong oxidizers as nitric acid, wet and dry chlorine, and acid solutions of salts. It is available in nearly all standard commercial forms.

For more information on HASTELLOY alloy C, get in touch with the nearest Haynes Stellite Company Office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation

WEED PROBLEMS?

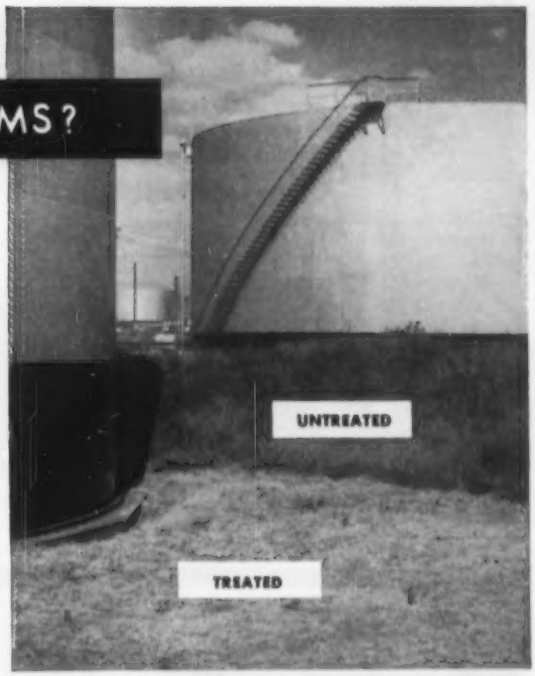
One application of

Du Pont Telvar®

WEED KILLERS

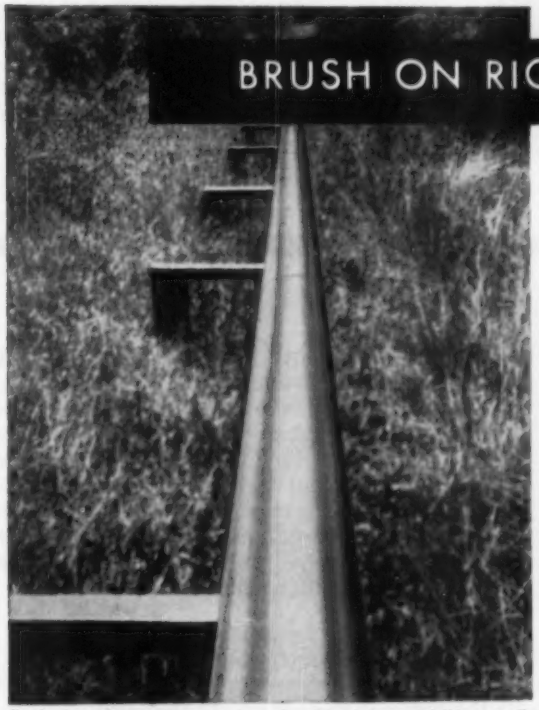
stops weeds for the season—or longer!

"Telvar" kills weeds through the roots . . . prevents regrowth. Low rates (20 to 80 lbs. per acre) make it cost little for the results you obtain . . . also mean less handling, fewer storage problems. To cut maintenance costs to new low levels, put "Telvar" in your weed-control program. Available in two formulations: "Telvar" W, and "Telvar" DW.



"Telvar" is ideal for weed control around tank farms, pipelines, pumps and derricks. It's non-toxic to humans and animals, non-flammable, non-volatile and non-corrosive to equipment.

BRUSH ON RIGHT-OF-WAY?



Brush along this pipeline was cleared and kept down with "Ammate." "Ammate" allows low-growing cover to return to resist erosion.

One application of

Du Pont Ammate®

WEED AND BRUSH KILLER

kills more kinds of brush —safely—at lower cost!

"Ammate" kills more kinds of brush and keeps it down longer than most weed and brush killers! When the original spray job is done well, brush is kept under control for years with only an occasional spot spray. You can rely on "Ammate" to do the job safely, even where your right-of-way adjoins cropland, because "Ammate" is not volatile. There are no vapors to drift onto sensitive crops. It is no hazard to crews, stock or wildlife.

FREE ILLUSTRATED BOOKLETS describe how to control weeds and brush with Du Pont chemicals. For your copies, write to Du Pont, Grasselli Chemicals Dept., Rm. D-4032, Wilmington, Del. In Canada, Du Pont Company of Canada Limited, Box 660, Montreal.

On all chemicals always follow directions for application. Where warning or caution statements on use of product are given, read them carefully.

Telvar® [Weed Killers for industrial use

DU PONT REG. U.S. PAT. OFF.

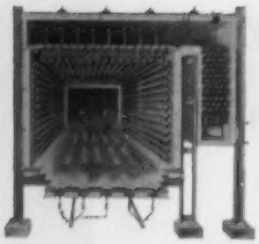
Ammate® Weed and Brush Killer

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTR

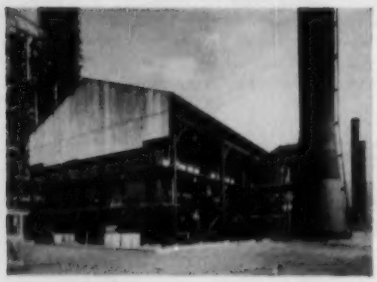
For more data on advertised products, use Readers' Service Cards, last page.

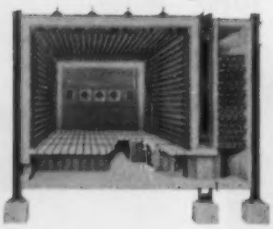
LUMMUS

OIL HEATER DIVISION
385 Madison Avenue, New York 17, N. Y.

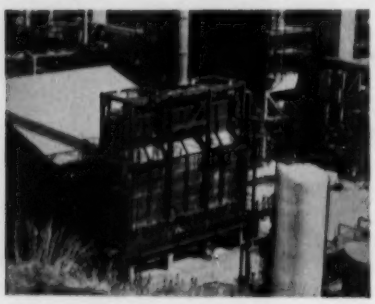


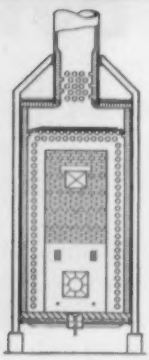
Lummus Standard Oil Heaters are made in two basic types. The up-take heater, illustrated at the left, conducts the products of combustion upward from the entire heating chamber at low and uniform levels of velocity.





The down-take heater, illustrated at the left, is suitable for service where products of combustion would contain corrosive elements or solid matter. It draws hot gases downward from the combustion chamber through the diffusion baffles. Both types of Lummus Standard Heaters are adaptable for multi-coil or multi-stage heating.





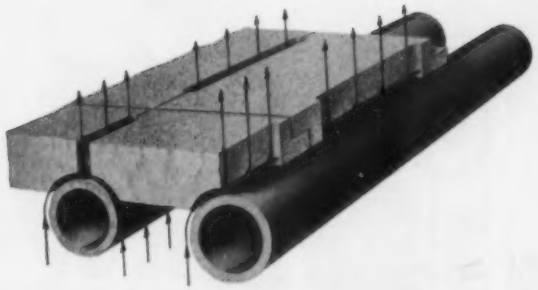
The Economy Heater, illustrated at the left, finds wide application in smaller refineries where the investment necessary for extensive maintenance platforms and roofing is not justified. The flexibility and variety of capacities available with multi-coil and multi-stage settings can be obtained with Lummus-Built Heaters in the same manner as with the larger Standard units.

Lummus Standard Oil Heaters and Lummus-Built Heaters are the answer to the vital problem of supplying process heat in any required amount for petroleum refineries, chemical and petro-chemical plants. Single Lummus Heaters are operating at continuous heat absorptions ranging from 100,000 to 300,000,000 BTU per hour. Lummus has designed and installed heaters for use with every major process.

BRANCH OFFICES — Houston: 2707 Weslayan Rd., Houston 6, Texas • England: The Lummus Co., Ltd., 80 Regent St., London W1, England • France: Societe Francaise des Techniques Lummus, 39 Rue Cambon, Paris 1er, France Holland: Lummus Nederland N.V., 56 Scheveningseweg, The Hague, Holland.

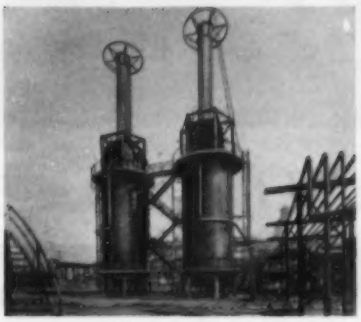
LUMMUS

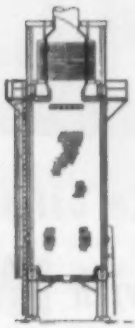
OIL HEATER DIVISION
385 Madison Avenue, New York 17, N. Y.



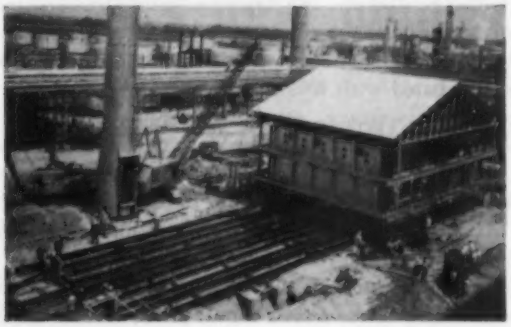
The patented gas diffusion baffle arrangement shown at the left is characteristic of Lummus furnaces. This arrangement creates a draft resistance or dampering effect which assures uniform evacuation of the products of combustion over the entire ceiling area of the combustion chamber.

Benefits obtained by the use of the slotted refractory baffle tile include high velocity gas flow over the shielded upper row of roof tubes—with consequent high convection heat pick-up—and re-radiated heat from the under side of the tile to the upper side of the bottom row of roof tubes.





Lummus-Built Heaters incorporate the same material, mechanical and operating advantages of the Lummus Standard Oil Heaters but are built along the more simplified and economical lines possible with their smaller size. The Lummus Vertical Tube Heater, illustrated at the left, for milder heat requirements, is especially designed for limited space installation.



The portable heater, left, was built for Magnolia in record time—a mere six weeks downtime compared with the usual five months. It is the height of flexibility and is a smooth-running 100,000,000 BTU per hour heater handling 36,000 B/D of charge stocks—an increase of several thousand barrels over the heater it replaced.

The heaters described above are, of course, Lummus designed. Lummus also has built and will build for you, if requested, counter-parts of all popular types of furnaces used in the petroleum, chemical and petro-chemical industries. Lummus can also build to your specifications any type of specialty heater that a particular production problem calls for. Lummus' 50 years of experience in constructing petroleum and chemical plants lies behind the work of the Oil Heater Division, providing the knowledge necessary to do any job requested by a customer—and to do it right.

BRANCH OFFICES — Chicago: 600 South Michigan Ave., Chicago 5, Illinois • Venezuela: Compania Anonima Venezolana Lummus, Edificio "Las Grandillas", Esquina Las Gradillas, Caracas, Venezuela • Canada: 455 Craig St. West, Montreal

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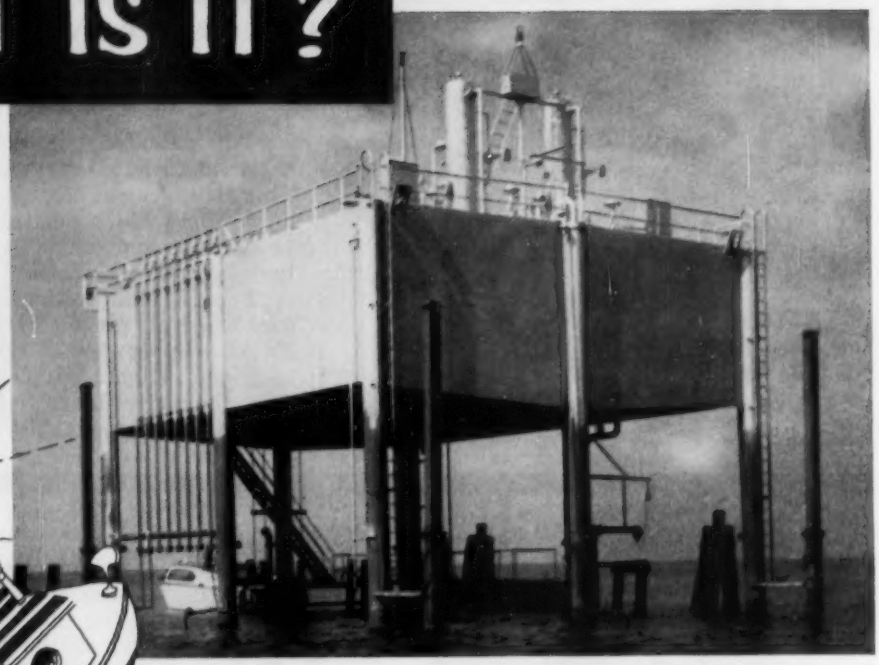
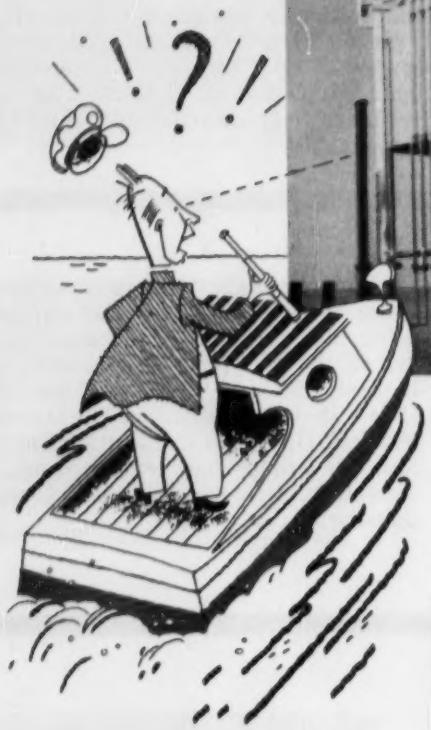
WHAT IS IT?





An off-shore oil tank coated with INSUL-MASTIC!

Thirteen miles off the shore of Corpus Christi stands this oil storage tank. An island on legs receiving oil from eight off-shore drilling rigs. The water is shallow, the heat and humidity are terrific. Evaporation is rapid and the atmosphere is among the saltiest and most corrosive on earth. That is why the sides and bottom of the island tank are coated with INSUL-MASTIC.

INSUL-MASTIC's heavy, reinforced asphaltic coatings also prevent corrosion in steel mills, paper pulp mills, chemical plants and other industries where the corrosive atmosphere is extremely severe. Claims and appearances can be duplicated, but INSUL-MASTIC's record for maintenance-free protection shows jobs 12, 15 and 20 years old . . . and that record cannot be duplicated.

To prevent corrosion in your plant, specify the protective coating which has stood the test of time. Specify INSUL-MASTIC and free yourself of corrosion and maintenance.

INSUL-MASTIC coatings are made only in the INSUL-MASTIC laboratories from a number of raw materials, each carefully selected for a particular function or quality. Among these are asphalt and Gilsonite.

Insul-Mastic

Think first of the coatings that last!

Representatives in Principal Cities

CORPORATION OF AMERICA • 7750 West 61st Place, Summit, Illinois

Extruded Incoloy tubes help keep gas reforming costs down. They are economical in cost and possess the necessary characteristics of strength, and heat- and corrosion-resistance. Shell reacts natural gas and steam in them at money-saving high pressures and temperatures.

How Incoloy reduces gas reforming costs in Shell's new anhydrous ammonia plant

High pressure, 1700°F reaction in extruded Incoloy tubes permits major operating economies

Today, anhydrous ammonia is cheap and plentiful . . .

A boon to dirt farmers in Southern California and Arizona. With it, they're growing big vegetables bigger than ever.

Shell Chemical Corporation makes this low-cost NH_3 in Pittsburgh, California and in its new plant at Ventura. They synthesize it from nitrogen plucked out of the air, hydrogen squeezed out of natural gas.

At the new plant, in the gas reforming stage, Incoloy* iron-nickel-chromium alloy helps Shell make several big economies.

Keeping the pressure high during the reforming operation results in a 25-30% saving in compressor horsepower when the synthesis gas is fed to the converters.

So Shell takes the natural gas at its high line pressure, heats it to 1700°F and reacts it with steam in extruded Incoloy tubes packed with catalyst.

This iron-nickel-chromium alloy provides the high creep and rupture strengths needed for this high temperature, high pressure reaction. It does not tend to suffer embrittlement as a result of phase changes. It resists oxidation and corrosive effects of the methane-steam mixture. What's more, the extruded tubes proved more economical than other materials considered for the application.

If your new developments include gas reforming at high pressures and temperatures, you may want to look into Incoloy. Just write Inco's High Temperature Engineering Section.

*Registered Trademark

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO Nickel Alloys

Incoloy . . . "for long-life at high temperatures"

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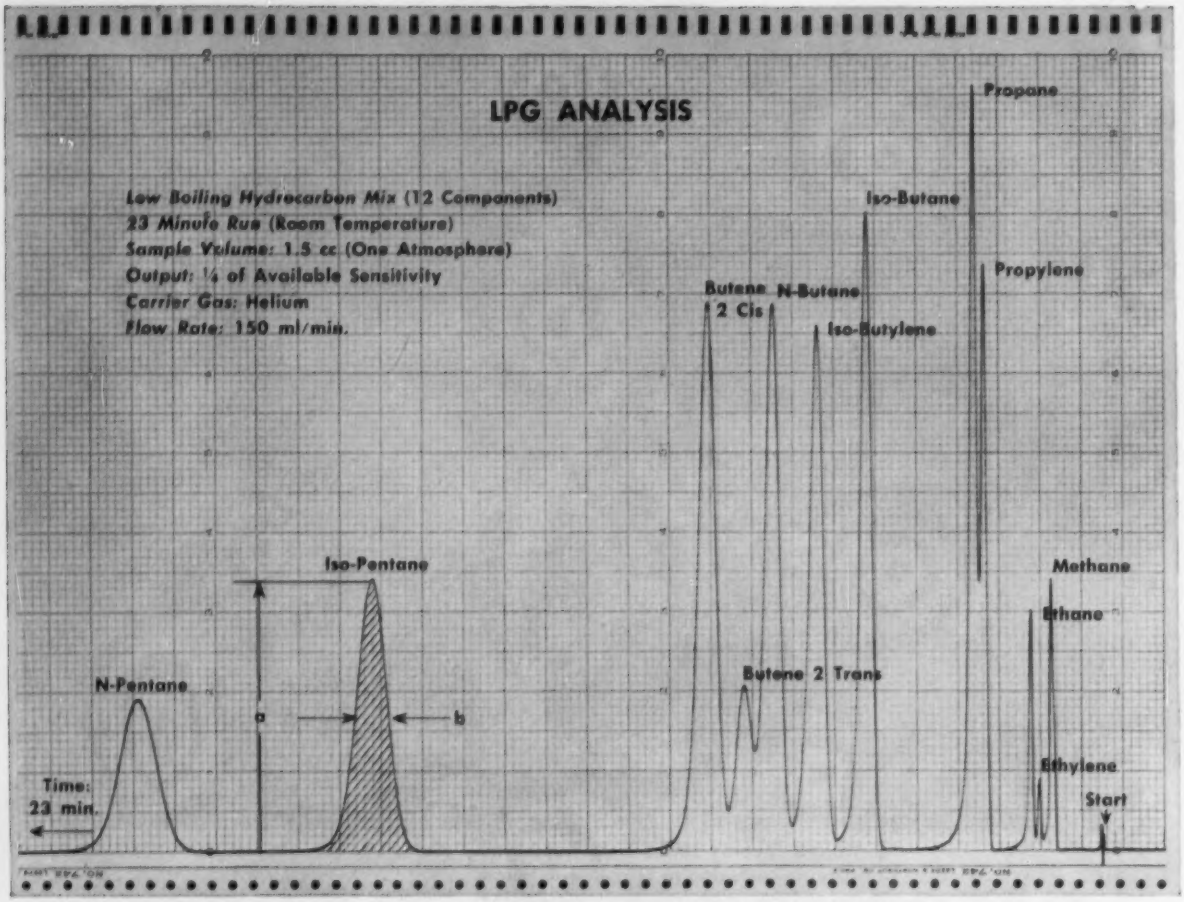


Photo of actual run made on new P-E Vapor Fractometer. To find mole % concentration of a component, analyst simply integrates area under peak by multiplying peak height (a) times half-band width (b).

This quantitative analysis took only 23 minutes on the new P-E Vapor Fractometer that costs only $1,375

HOW LONG WOULD IT TAKE YOU?

Employing the principles of gas chromotography, P-E's new vapor fractometer is a revolutionary advance in the field of gas and volatile-liquid quantitative analysis. It is fast, precise, uncomplicated to operate, extremely simple in calculation, and above all, many times less expensive than distillation columns, mass spectrometer, or any other instrument for the purpose.

For qualitative analysis, the instrument gives extremely clean separations—even of components and isomers which cannot be separated by ordinary methods. For trace analysis, high sensitivity permits use of extremely small samples.

Take, for example, the analysis of a synthetic LPG mix shown above. Here 12 components, representing the hydrocarbons most frequently encountered, were clearly separated—a job extremely difficult to accomplish by ordinary vacuum distillation methods. The perfect shape of the recorder bands makes quantitative analysis simple and accurate. Area under each peak is the measure of the mole % concentration of the component. These area relationships are all that is needed for calculation, without preliminary calibration for each individual component.

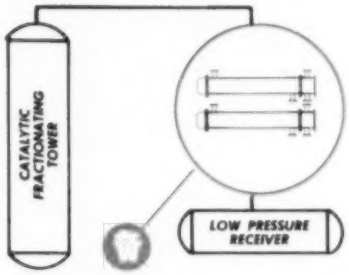
There is no faster, no simpler, no more inexpensive method in existence today.

This is the Model 154 Vapor Fractometer—price, $1375.00 without recorder. Send for descriptive bulletin.

Perkin-Elmer CORPORATION

Norwalk, Connecticut

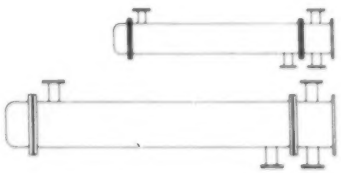
No. 11 in a series designed to help you achieve greater heat transfer efficiency.



NEW "CAT" FRACTIONATOR OVERHEAD CONDENSERS TUBED WITH WOLVERINE TRUFIN* TYPE S/T CONDENSER TUBE

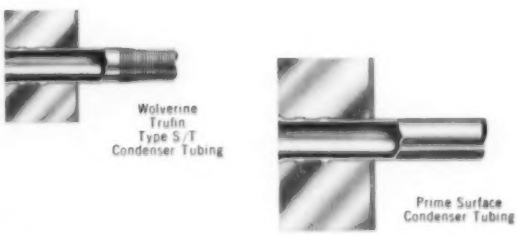
1

INCREASED EFFICIENCY—Trufin Type S/T is an extended surface tube with its fins an integral part of the tube wall. Because of this, Type S/T has more than two times the heat transfer surface of prime surface tube—extracts more BTU's per foot of tube. Shown here are comparable lengths of tube for equivalent heat transfer surfaces.



2

LOWER COST—Type S/T's additional outside surface area permits the use of less tube for a given heat duty. You get smaller shells, baffles, reduce fabricating costs with lower maintenance because there are less tubes to clean.



3

EASY INSTALLATION—Trufin Type S/T rolls into headers as easily as plain tube—uses the same fabrication methods. Standard rolling-in tools are used. There is no deviation from existing fabrication procedures.

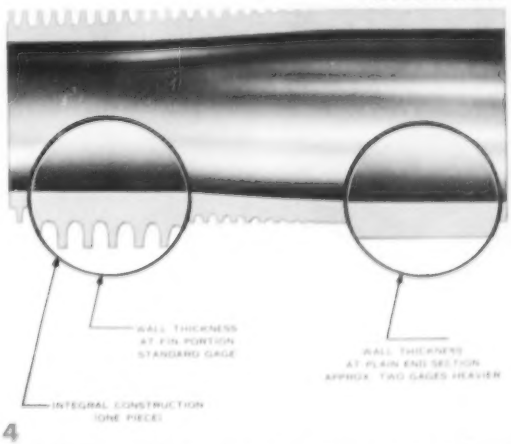
Because of Wolverine Trufin Type S/T condenser tube, new standards of efficiency and economy are daily being established in the field of heat transfer. Diagramed above is another Trufin installation—this time the condensing, for a large Midwest refinery, of hydrocarbon overhead vapors from a catalytic cracking unit fractionating tower.

Illustrated here are four solid reasons why this company specified Trufin Type S/T for the job.

Wolverine Trufin Type S/T will work exactly the same for you as it does for this company. Put it to the test—specify it next time you retube existing equipment or are contemplating the design of new units. Write today for your copy of the Trufin Opportunity Book—it's filled with dramatic case histories and helpful design information.

Wolverine Tube, 1437 Central Ave., Detroit 9, Michigan.

*REG. U.S. PAT. OFF.


WALL THICKNESS AT FIN PORTION STANDARD GAGE
WALL THICKNESS AT PLAIN END SECTION APPROX. TWO GAGES HEAVIER
INTEGRAL CONSTRUCTION (ONE PIECE)

4

ENGINEERED FOR THE JOB—Trufin Type S/T is specifically designed for shell and tube applications. The cutaway photograph illustrates its unique, one-piece construction. Because of this, Type S/T gives constant efficiency—its fins are unaffected by thermal shock, vibration or varying pressures.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

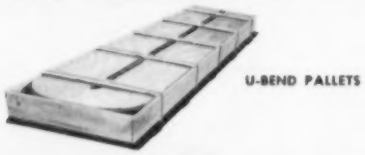
MANUFACTURERS OF QUALITY-CONTROLLED TUBING AND EXTRUDED ALUMINUM SHAPES

You Asked Us

Here are some of the questions which have been answered recently by Wolverine Field Engineering Service. It is active proof of Wolverine Tube's versatility.

Q. We changed our plant operation recently and now we're having severe corrosion problems. On one heat exchanger we have entirely different corrosion conditions on the shell side than we do on the tube side. What can we do to overcome this?

A. ***When two entirely different corrosive conditions are encountered, Wolverine can supply a Duplex tube—one which consists of two tubes of entirely different alloys. For example, a combination commonly used in water cooled ammonia condensers is an electric-welded steel outer tube with a liner of admiralty or copper. Any two metals can be used—the determining factor simply being the type of corrosion encountered. Of course, if you want more surface you can specify Duplex Type S/T condenser tubing. You not only get two different metals but also integral fins to increase the heat transfer surface.***



Q. Recently we used our first installation of Wolverine U-Bend condenser tubes. Can we obtain finned tube in U-Bend form?

A. ***You sure can. Wolverine U-Bends are available in both finned and prime surface condenser tube—pre-arranged to your prints.***

Q. On some jobs we've been using steel condenser tubing and there are a few cases where we'd like to obtain more surface. What do you suggest?

A. ***Actually you're in luck—On the exchangers where you want additional surface you can use Wolverine Trufin Type S/T welded steel condenser tubing. That will give you the surface you want. On those other heat exchangers where additional surface is not required you can retube them with Wolverine Qualitube*—our prime surface electric-welded steel condenser tube. You'll get long life plus a low-cost installation.***

Q. Can we use Wolverine Trufin Type S/T condenser tubing at high temperatures?

A. ***Yes. Type S/T is an integral finned tube, as are all other types of Trufin. The fins are squeezed directly from the tube wall— are a part of the tube itself. They cannot shake loose because of thermal shock, vibration or varying pressures. Trufin is also available in bi-metal: high finned aluminum exterior and an inner liner of your choice.***

If you have a question—whether it be about alloys, design or fabrication—bring it to Wolverine. You'll get the right answer and you'll also get exactly the right condenser tube to help you do a better job. Write, too, for your copy of the Wolverine Condenser Tube Catalog. WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.

*REG. U.S. PATENT OFFICE

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

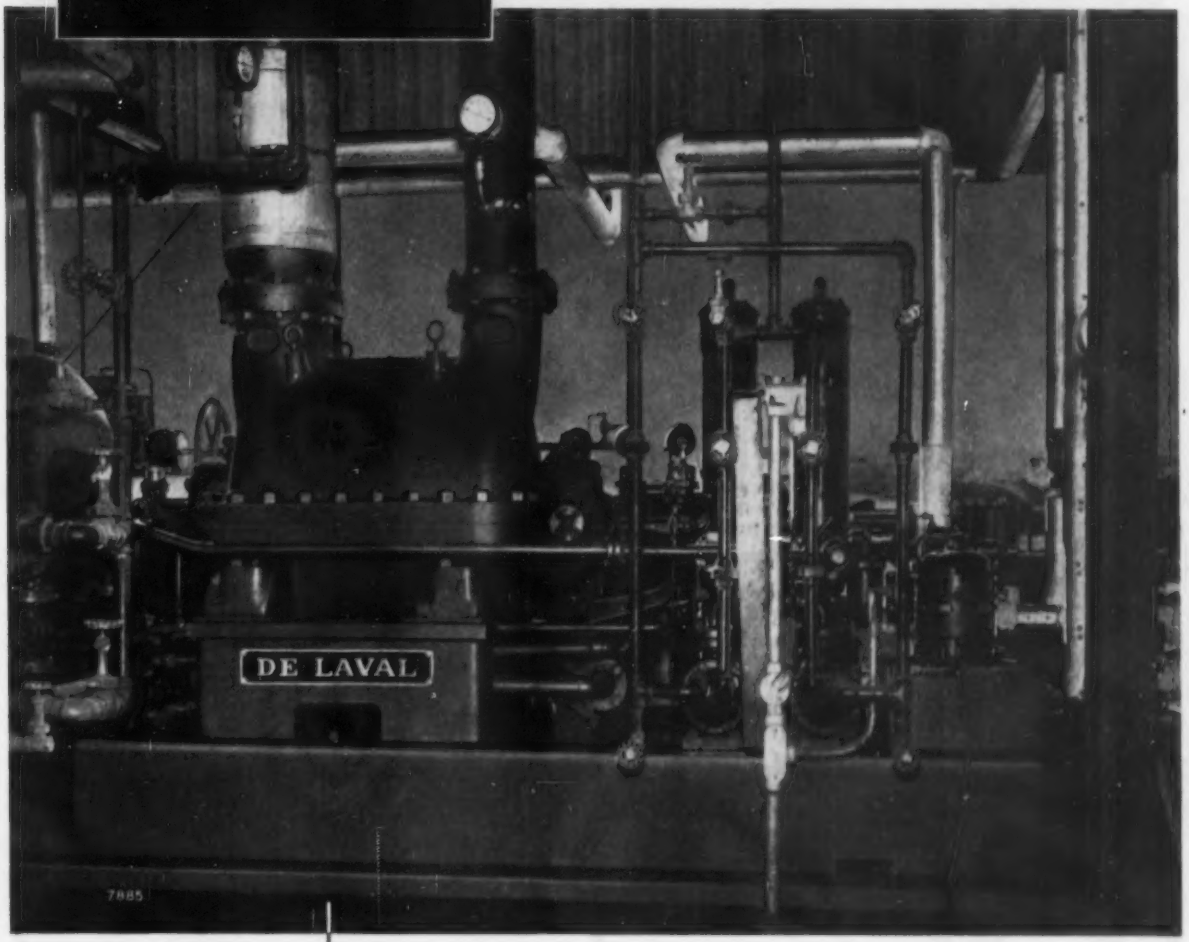
MANUFACTURERS OF QUALITY-CONTROLLED TUBING AND EXTRUDED ALUMINUM SHAPES

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT., 13 E. 40TH ST., NEW YORK 16, N.Y.

DE LAVAL CENTRIFUGAL COMPRESSOR

handles propane-butane for M. W. Kellogg alkylation unit



New Bulletin 0504 gives complete data

On stream at a plant of a large mid-western refiner, this De Laval unit compresses the propane-butane mixture to prepare it for an M. W. Kellogg alkylation unit.

Inlet volume of the De Laval centrifugal compressor is 3,040 cubic feet per minute. Inlet pressure is 18 psia, and discharge pressure 85 psia. This compressor is equipped with De Laval contact-type oil seals. The unit is driven by a 600 bhp turbine running at 7,400 rpm.

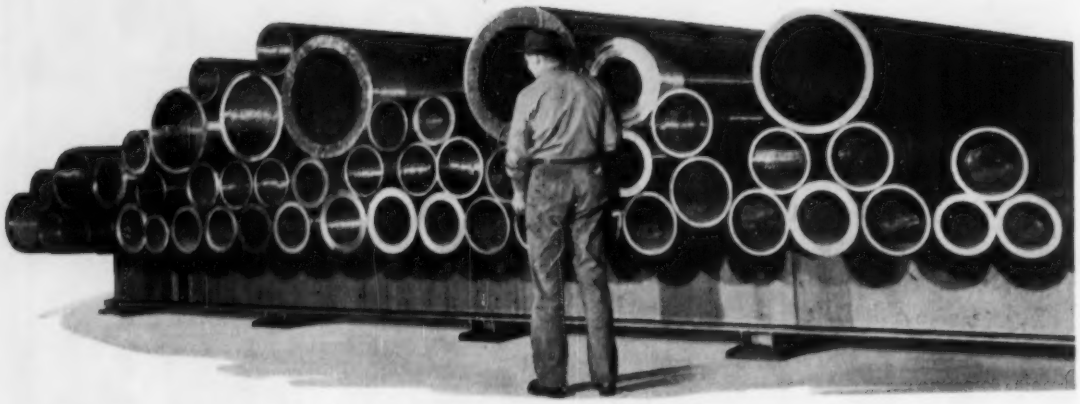
De Laval compressors are designed and built for heavy duty continuous operation. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings assure optimum performance and long service.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL 309

B&W Offers
HOLLOW FORGINGS In A Wide Range of Sizes



B&W Hollow Forgings are produced in a large range of fractional inch sizes and a selected range of standard pipe sizes in accordance with the following ASTM Specifications: A 106-52T seamless carbon steel pipe for high-temperature service. A 266-54 carbon steel seamless drum forgings. A 312-54T seamless and welded austenitic stainless steel pipe. A 335-53T seamless ferritic alloy steel pipe for high-temperature service. A 376-54T seamless austenitic steel pipe for high-temperature central-station service.

Carbon Steel and Intermediate Alloys

Outside Diameter: 9¼ inches to 35¾ inches
Wall Thickness: ¾ inch to 5⅜ inches

STANDARD PIPE SIZES
AVAILABLE AS HOLLOW FORGINGS

Size Inches	Nom. OD Inches	Schedule Nos.
10	10¾	120–140–160
12	12¾	100–120–140–160
14	14	100–120–140–160
16	16	80–100–120–140–160
18	18	100–120–140–160
20	20	100–120–140–160
24	24	100–120–140–160

These pipe sizes are in complete agreement with ASA standard No. B36.10-1950.

Austenitic Stainless Steels

Outside Diameter: 9¼ inches to 33¾ inches
Wall Thickness: ½ inch to 4½ inches

MINIMUM WALL EQUIVALENTS OF
STANDARD PIPE SIZES AVAILABLE
AS STAINLESS STEEL HOLLOW FORGINGS

Size Inches	Nom. OD Inches	Schedule Nos.
10	10¾	80–100–120–140–160
12	12¾	60–80–100–120–140–160
14	14	60–80–100–120–140–160
16	16	60–80–100–120–140–160
18	18	80–100–120–140–160
20	20	100–120–140–160
24	24	100–120–140–160

For the complete range of B&W Hollow Forgings plus other important information on what B&W has to offer you in Hollow Forgings, send for Bulletin S-16B. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

BABCOCK & WILCOX
BOILER DIVISION

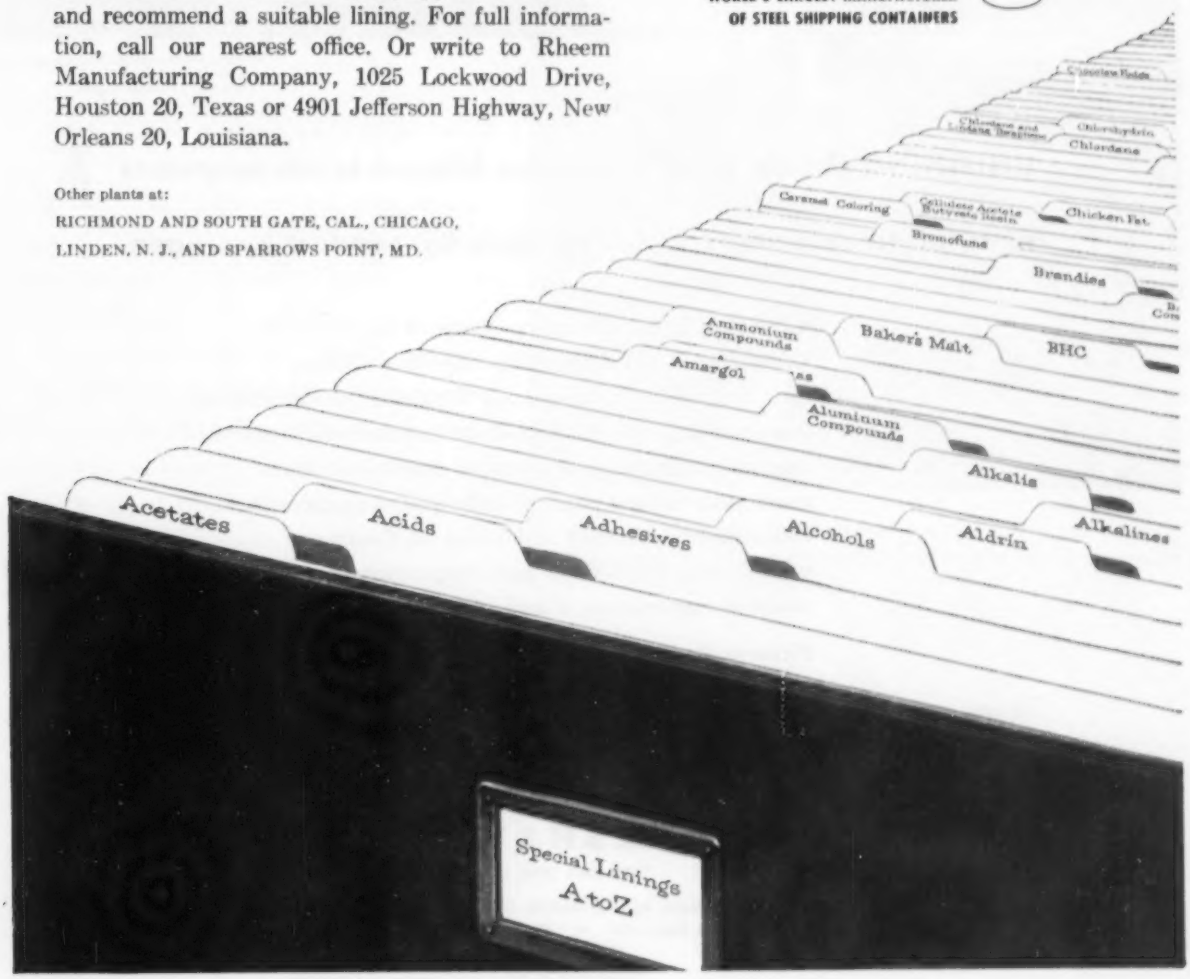
S-446

Whatever your product, chances are that Rheem has already developed special linings to protect it for shipment in steel drums

Rheem's experience with hard-to-package products is a matter of record. From acetates to white oils, virtually any bulk-packaged product you can think of is now being shipped in Rheem-built steel drums and pails with special linings.

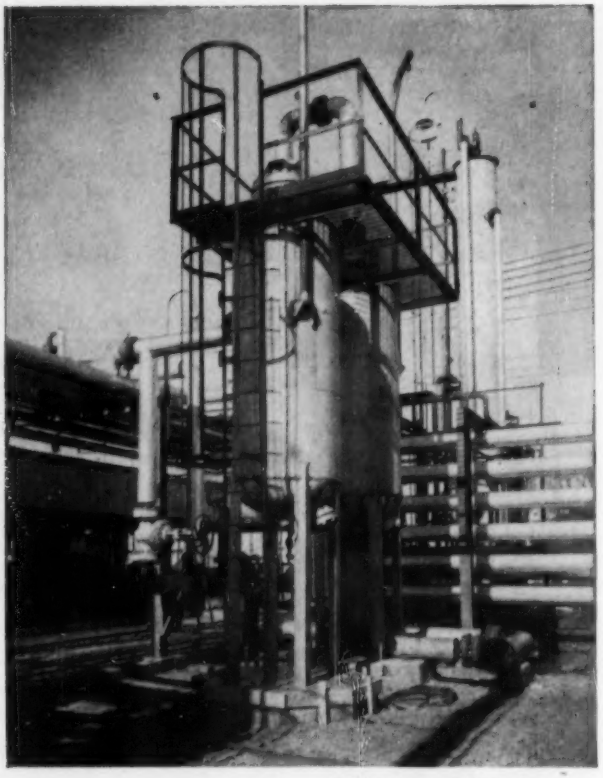
So you name it. If you have a product you'd like to ship in steel containers, chances are that we've already developed a lining that will protect it. If it's a new product, or one that we've never handled, Rheem laboratories are fully equipped to run tests and recommend a suitable lining. For full information, call our nearest office. Or write to Rheem Manufacturing Company, 1025 Lockwood Drive, Houston 20, Texas or 4901 Jefferson Highway, New Orleans 20, Louisiana.

Other plants at:
RICHMOND AND SOUTH GATE, CAL., CHICAGO, LINDEN, N. J., AND SPARROWS POINT, MD.



For more data on advertised products, use Readers' Service Cards, last page.

INTERESTED IN UNIFINING* FOR DESULFURIZATION AND UPGRADING



● First Commercial Unifining Unit
United Refining Co.
Warren, Pennsylvania

UNIFINING should be of particular interest to all operators of catalytic reformers which produce by-product hydrogen.

● Harshaw is the exclusive producer of the Union Oil Company of California cobalt-molybdate catalyst used in the recently announced "Unifining" desulfurization and upgrading process. This rugged, commercially proven catalyst is supplied in the form of cylindrical tablets conforming to rigid physical and chemical specifications established by Harshaw and Union Oil Company of California. Stability at high temperatures permits repeated regenerations if and when necessary.

Please contact Harshaw for further information on this catalyst.

HARSHAW

THE HARSHAW CHEMICAL CO.

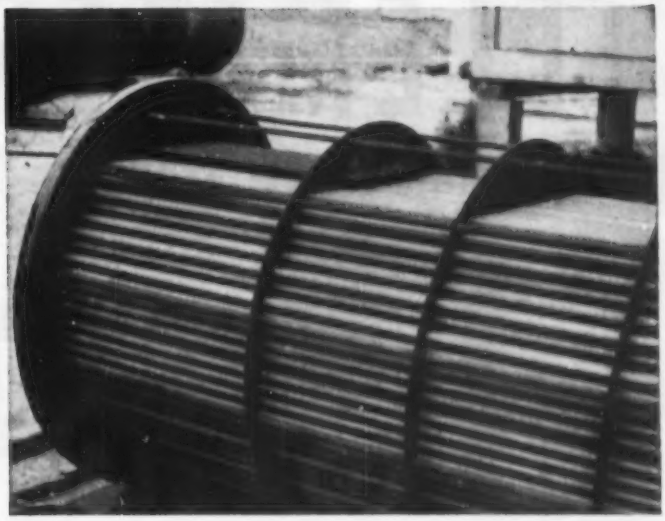
1945 East 97th Street, Cleveland 6, Ohio

Chicago 32, Illinois • Cincinnati 13, Ohio • Detroit 28, Michigan • Houston 11, Texas
Los Angeles 22, California • New York 17, N. Y. • Philadelphia 48, Pennsylvania
Pittsburgh 22, Pennsylvania

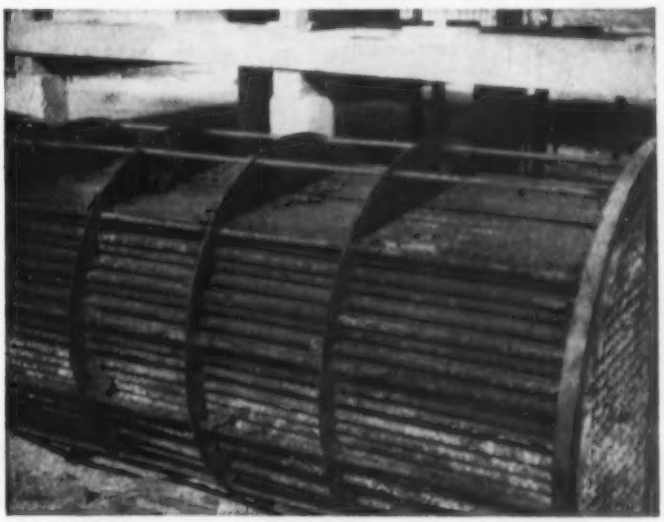
*Trademark of Union Oil Company of California

Which bundle do you want to find

at turn-around time?



This?.. Here's what a refiner likes to see when he pulls his bundles at turn-around time. This clean, uncorroded appearance is typical of what can be expected when you use Polyrad.



or this?.. This is an all too common sight at turn-around time. Corroded and fouled bundles such as these call either for costly replacement, repair, or cleaning.

These two bundles from the overhead condensing system of a Gulf Coast refinery tell a story. One is what the refiner likes to find at turn-around time; the other, what he is likely to discover without Polyrad.

More and more refineries have found that when they use Polyrad, the filming amine inhibitor, they can expect to find bundles free of corrosion, ready for immediate return to service. As a result turn-around time no longer need be headache time.

Why not make use of Polyrad's detergency to maintain throughput, increase heat transfer, and cut down time for maintenance?

Stocks of Polyrad are maintained throughout the country. A Hercules technical representative will be glad to discuss its application to your operating conditions.

POLYRAD®

FILMING AMINE INHIBITOR

Pine Chemicals Division, Naval Stores Dept. **HERCULES POWDER COMPANY** *976 Market Street, Wilmington 99, Delaware*

NASS-6

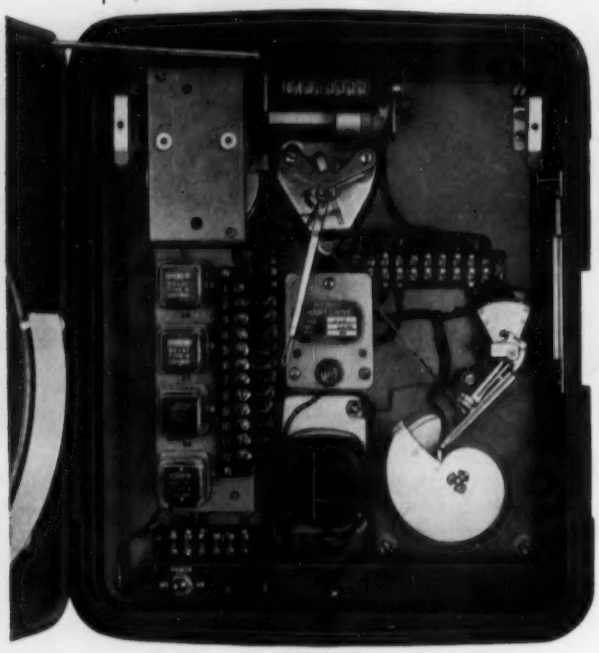
For more data on advertised products, use Readers' Service Cards, last page.

TELEMETERING

with unique new freedom from maintenance!

Transmitter

ANY TRANSMISSION SYSTEM
two wires
one wire and ground
radio or microwave
carrier current



Receiver

TELETAX by Foxboro

You can now get the full benefit of Foxboro accuracy and reliability for *remote* measurements, too! Teletax, the Foxboro impulse-duration system, brings new durability and simplicity to telemetering. For example, in the compact Teletax Receiver, dust-proof, plug-in relays and a husky reversing motor drive the recording pen positively. Maintenance is all but eliminated. And when servicing *is* necessary, *every* component is easily replaceable as a separate unit.

Teletax will transmit any measurement made with standard Foxboro measuring elements. Accuracy is ½% of full scale . . . regardless of normal variations in signal strength. Get full details on Teletax efficiency and economy. Write for Bulletin 17-11.

Most Practical System You Can Get!

RELIABLE: Thoroughly proved in actual field installations.

ECONOMICAL: Operates on lowest-cost transmission circuits.

LOW MAINTENANCE: A few drops of oil in the receiver motor every three months is all that's required; low 5 ma dc signal avoids failures.

Single or dual transmitter or receiver; indicating or recording; totalizing available.

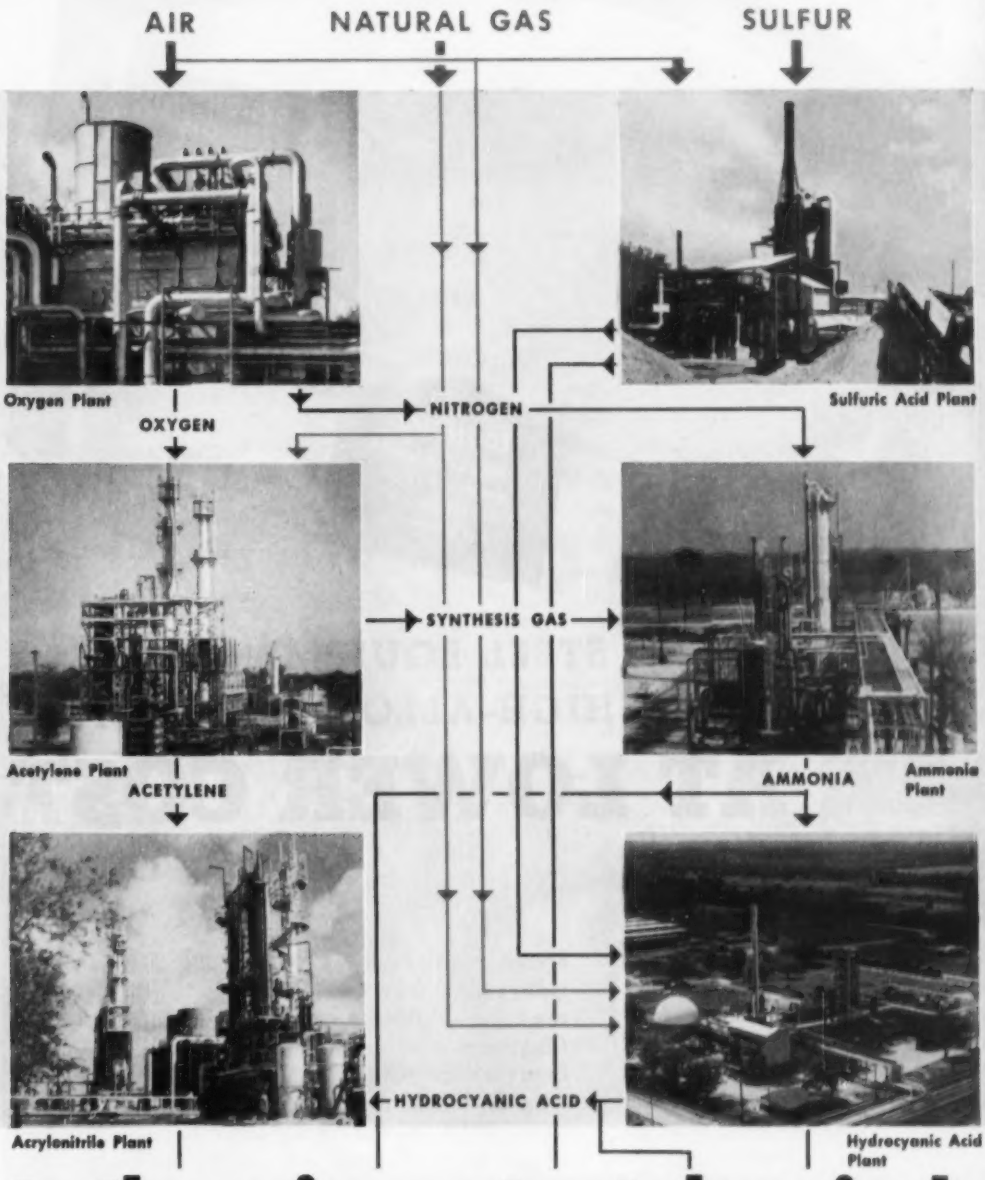
THE FOXBORO COMPANY, 7411 NEPONSET AVENUE, FOXBORO, MASSACHUSETTS, U.S.A.

FOXBORO
REG. U. S. PAT. OFF.

TELETAX
(impulse-duration) Telemetering

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

From these raw materials...



to these important chemicals

ACRYLO-NITRILE | AMMONIA | SULFURIC ACID | HYDRO-CYANIC ACID | AMMONIUM SULFATE

The Fortier Plant of American Cyanamid Company, Avondale, Louisiana, designed and constructed by CHEMICO

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

525 WEST 43RD STREET, NEW YORK 36, NEW YORK

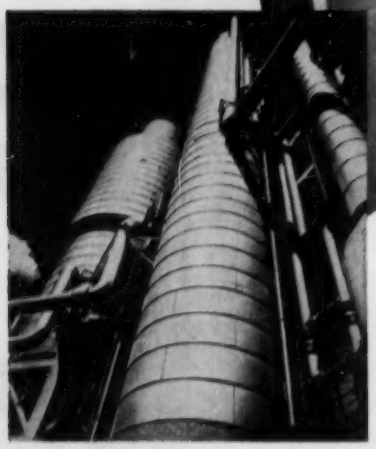
Cable Address: Chemiconst, New York • Technical Representatives: Cyanamid Products Ltd, London South African Cyanamid (Pty) Ltd., Johannesburg

CC-803

CHEMICO

CHEMICO CHEMICAL CONSTRUCTION CORPORATION

STRUCTURAL STABILITY—
Low-cost carbon steel backing provides necessary strength and rigidity.
DESIGN FREEDOM—
Integral bond allows design and fabrication of shapes to meet process and space needs.
ECONOMY—
High-alloy layer assures corrosion resistance, long equipment life.



Stainless-clad and monel-clad steels combine to handle corrosive asphalt crude containing up to 2.5% sulfur concentrations at 750° F in this vacuum still.

CLAD STEEL EQUIPMENT GIVES SOLID HIGH-ALLOY PROTECTION AT LOWER COST

With protection against the corrosive action of sulfuric feeds at high temperatures a "must" to avoid unscheduled shutdowns, clad steel equipment is often the *economical* answer. Cladding and backing are permanently and integrally bonded over their entire surface, eliminate the chance of seepage or crevice corrosion. Smooth, uniform clad surfaces permit easy cleaning, drainage and inspection.

Why not investigate clad for your new processing equipment. Lukens Clad Steels—stainless, nickel, Inconel, Monel, copper—give you all the advantages of these solid high-alloys with savings up to 50% in material costs.

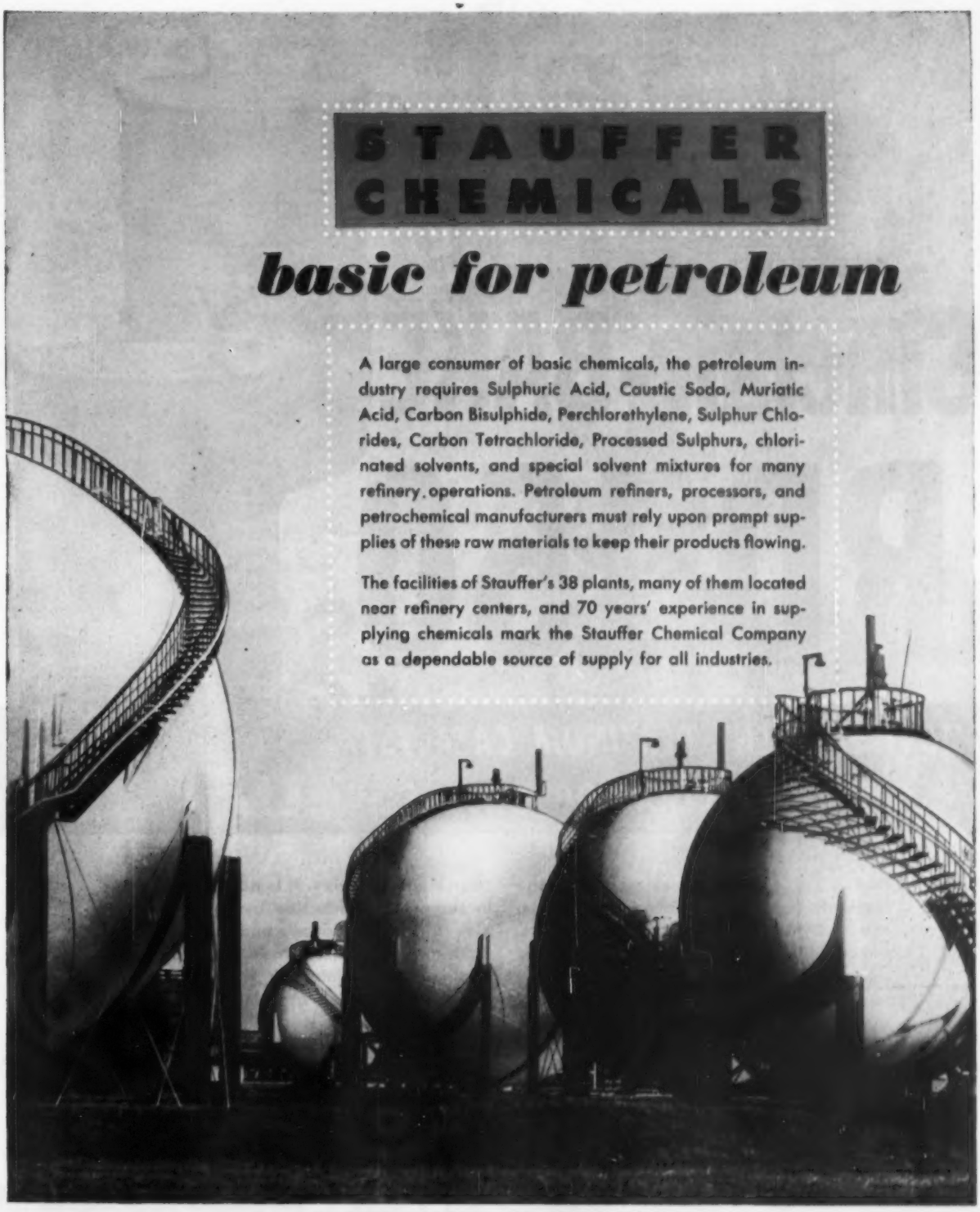
In addition to low first cost, clad steel permits easy and economical field erection. When you're thinking of new tanks and pressure vessels, *qualified* equipment builders can help you take advantage of the versatility of Lukens Clad Steels. Working with your engineers and consultants from the start, they tailor equipment to your exact needs. We offer the widest range of clad steels available and work closely with fabricators to help select the type most suited to your processing needs. If you would like further information, ask one of your builders or write Manager, Marketing Service, Lukens Steel Company, 750 Lukens Building, Coatesville, Pennsylvania.

LUKENS CLAD STEELS

Visit Our Exhibit at the
CHEMICAL SHOW
Dec. 2-9, 1955 Booth No. 66

STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEEL PLATES AND HEADS AVAILABLE


STAUFFER
CHEMICALS
basic for petroleum
A large consumer of basic chemicals, the petroleum industry requires Sulphuric Acid, Caustic Soda, Muriatic Acid, Carbon Bisulphide, Perchlorethylene, Sulphur Chlorides, Carbon Tetrachloride, Processed Sulphurs, chlorinated solvents, and special solvent mixtures for many refinery operations. Petroleum refiners, processors, and petrochemical manufacturers must rely upon prompt supplies of these raw materials to keep their products flowing.
The facilities of Stauffer's 38 plants, many of them located near refinery centers, and 70 years' experience in supplying chemicals mark the Stauffer Chemical Company as a dependable source of supply for all industries.

380 Madison Avenue, New York 17, N. Y.

221 N. La Salle St., Chicago 1, Ill. • 636 California St., San Francisco 8, California
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STAUFFER CHEMICALS

Stauffer CHEMICALS SINCE 1885

For more data on advertised products, use Readers' Service Cards, last page.

Sinclair-BAKER

RD 150

"...MOST EFFICIENT PLATINUM CATALYST FOR HIGH OCTANE OPERATIONS..."

BAKER'S RD 150 is proving to be the most efficient of all reforming catalysts, *especially* so for high octane operations. Baker's RD 150 assures important yield increases at high octane levels . . . long periods of operation . . . and *regeneration in situ!* The practical advantages offered by RD 150 results in low cost operation.

RD 150 is a joint development of Baker & Company, Inc. and Sinclair Research Laboratories. It is now being used in successful production by such companies as Sinclair, Socony and Pure Oil.

The very extensive facilities for manufacture and refining in modern Baker plants, provide full assurance of prompt deliveries and service.

The complete RD 150 story will be interesting to you. A Baker representative will be glad to give you detailed information, upon request.

113 ASTOR STREET
NEWARK, N. J.

BAKER & COMPANY, INC.
CATALYSTS

THE HUB OF PLATINUM METALS RESEARCH

IT GRABS 360 POUNDS OF WATER FROM INSTRUMENT AIR EVERY DAY!

IT'S A PRITCHARD HYDRYER*—the packaged dryer that has proved itself in so many refinery operations

This particular HYDRYER is at Union Oil Company of California's Wilmington plant. It is capable of removing 360 pounds of water from instrument air every 24 hours. It dries 600 SCFM of instrument air at 50-60 psig and 90°F.

A HYDRYER can eliminate your moisture problems, too, and cut out costly plant and equipment shutdowns due to moisture and ice. A HYDRYER protects instruments and controls. It reduces corrosion, line losses, flow stoppages.

*Registered Trade Name

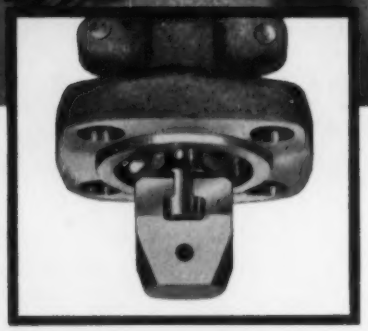
INDUSTRY'S PARTNER FOR PROGRESS

COOLING TOWERS
S & AIR TREATING EQUIPMENT

REPRESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

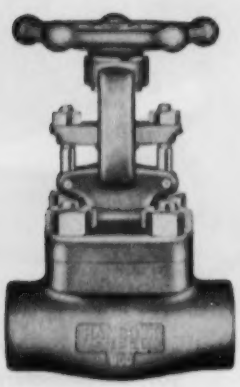
J.F. Pritchard & Co.
OF CALIFORNIA
A DIVISION OF J. F. PRITCHARD & CO.
Dept. 442, 4625 Roanoke Parkway, Kansas City 12, Mo.

LEARN HOW A HYDRYER can benefit you by sending for your complimentary copy of Pritchard's Bulletin No. 16.0.081, Write for it today on your company letterhead.



STAMINA

that takes heavy loading



THE STEM-WEDGE CONNECTION in Type 950 Hancock Steel Gate Valve won't bend or fracture even if corrosion prevents opening the valve. So strong is the connection that destructive "cheater" loading on the handwheel will first break the stem thread. The operator thus knows that the valve is still closed and can act to safeguard equipment and avoid shutdowns.

This ultra-strong stem-wedge connection, *an exclusive Hancock design*, overcomes a structural weakness widely recognized in other small gate valves. Its balanced design also places the "T" head slot in the wedge so that the stem can move freely, even though flow forces the wedge against the guides. It is a powerful example of the quality that makes Type 950 Hancock Steel Gate Valves perform better and longer in the severest services. Call your Industrial Supply Distributor for full details today.

HANCOCK VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Watertown 72, Massachusetts

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

Carrier Centrifugal Compressor

on the job at

Sinclair Refining Co.

This Carrier Centrifugal Compressor is on the job at the Sinclair Refining Company's Corpus Christi, Texas, refinery. Handling 2195 cfm of isobutane, the compressor is turbine-driven by exhaust steam.

Carrier makes a complete line of centrifugals for gas compression and refrigeration—up to 10,000 hp in a single unit. There are hundreds of these dependable, efficient Carrier machines on the job at dozens of chemical plants and refineries across the country—serving such companies as The Atlantic Refining Company, Reichhold Chemicals Company, Cities Service Company, Wyandotte Chemicals Corporation, Standard Oil Company of California. May we assist *you?*

If you'd like a copy of our informative booklet,

"Centrifugal Compressors for Industry,"

please call your nearest Carrier office. Or write direct to Carrier Corporation, Syracuse, New York.

Carrier

centrifugal compressors
refrigerating equipment

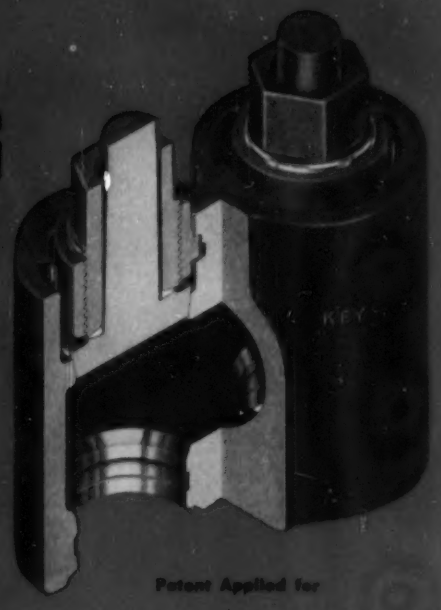
For more data on advertised products, use Readers' Service Cards, last page.

STANDARDIZE ON THIS FITTING AND YOU'LL REDUCE INVENTORY... SAVE MONEY...

it's the NEW 5000 TYPE KEY® RETURN BEND FITTING

WITH HIGH DEGREE OF INTERCHANGEABILITY

TWO SERIES:
850 and 1275 LBS.
NINE FITTINGS
in each series



Patent Applied for

850 lb. and 1275 lb. series

Fitting Size	Plug Number	Holding Member Number	Screw Number	Thrust Ring Number
2½	8Y1	2Y1	9Y1	D-13011
3	8Y2	2Y2	9Y2	D-13012
3½	8Y3	2Y3		
4	8Y4	2Y4		
4½	8Y5	2Y5	9Y3	D-13013
5	8Y6	2Y6		
5½	8Y7	2Y7		
6	8Y8	2Y8	9Y4	D-9356
6½	8Y9	2Y9		

A TOTAL OF 18 FITTINGS, BUT REQUIRING ONLY 26 PARTS INSTEAD OF 72

HEADING UP OPERATION
Holding member and screw may be handled as a unit.

UNHEADING
A slight loosening of the screw permits holding member and screw to be removed as a unit. The stem has been designed to withstand plug removal by striking with a hammer.

SAFETY FEATURE
Plug can be loosened before a holding member is disengaged, preventing the possibility of the plug blowing out of fitting as the result of build up of back pressure.

DAMAGED PARTS
If threads become damaged or frozen, holding mechanism can be removed by turning the breech.

STRESS DISTRIBUTION
Elliptical crossovers in the 5000-type give a maximum uniform distribution of stress. Plug hole section will be more uniformly stressed because of the added support of the 360° projection immediately above the plug seat.

METAL IN TENSION
The tension load is evenly distributed throughout the 360° circular projection.

SHEAR
The shear load is evenly distributed over 180°.

BENDING
No bending can occur in the holding member and the full 360° projection above the plug seat prevents bending of the lugs.

All parts of the 5000-type fitting, exclusive of the body casting, are available for immediate shipment from stock.

Write for information and prices now

key company

SINCE 1916... MANUFACTURERS AND DEVELOPERS OF PRODUCTS FOR HIGH TEMPERATURES AND PRESSURES

P. O. BOX 494-E EAST ST. LOUIS, ILLINOIS

A DIVISION OF O.C.F. INDUSTRIES INCORPORATED

DISTRICT OFFICES: NEW YORK • CLEVELAND • CHICAGO • TULSA • HOUSTON • LOS ANGELES

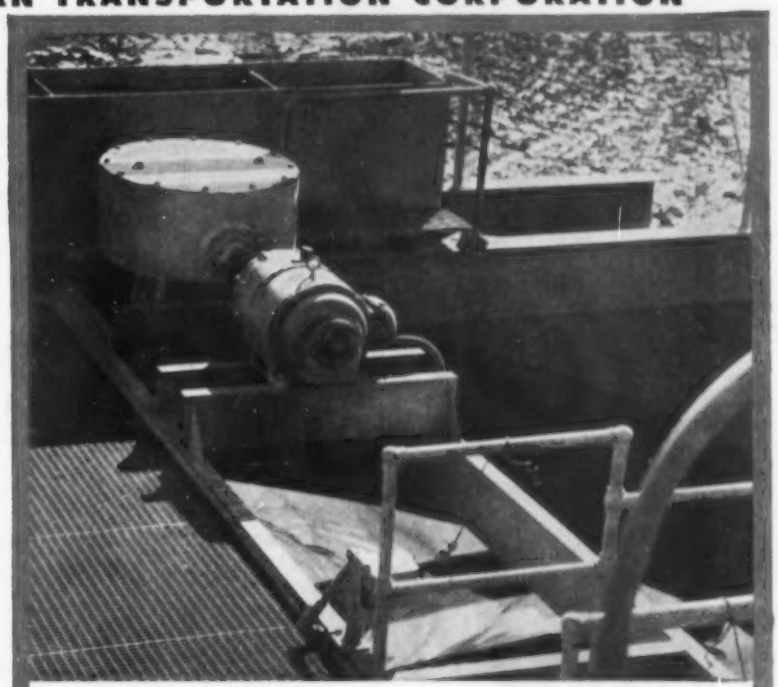
Turbo-Topics

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXER, a division of

GENERAL AMERICAN TRANSPORTATION CORPORATION

100,000 hours of round-the-clock service with TURBO on the job



One of the two Turbo-Mixers installed in 1941 at Universal Atlas Cement Company at Northampton, Pennsylvania, in cement slurry suspension.

Today, after *100,000 hours* of heavy-duty, *24-hour service*, these Turbos continue to operate with no more than normal plant maintenance. They are typical of the thousands of Turbos operating in continuous-flow processes where "down-time" is critical—where low maintenance is essential.

Turbos can help solve your agitation problems, whether your business is petroleum processing, chemicals, pharmaceuticals or minerals beneficiation. Turbo's built-in ruggedness that permits continuous 24-hour heavy-duty service assures you of "headache-free" production and lower costs in the long run.

SALES OFFICE: 380 MADISON AVENUE, NEW YORK 17, NEW YORK

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For more data on advertised products, use Readers' Service Cards, last page.

Net game or Net gain...

there's enough difference to make ALL the difference

In tournament tennis, a player's net game is one of the differences that make a champion. Likewise, significant differences in quality and performance engineered into Scovill Heat Exchanger Tube add up to a *net gain* for you in better operating results and less frequent maintenance shutdown of key units.

Scovill Phosphorized Admiralty Heat Exchanger Tube is "born" differently. It is initially hot-extruded from billets *continuous-cast* by Scovill's pioneer process. The result is sound metal through and through — smooth, dense, free from pits or porosity — and a new uniformity of chemical composition, with optimum, evenly distributed phosphorus content.

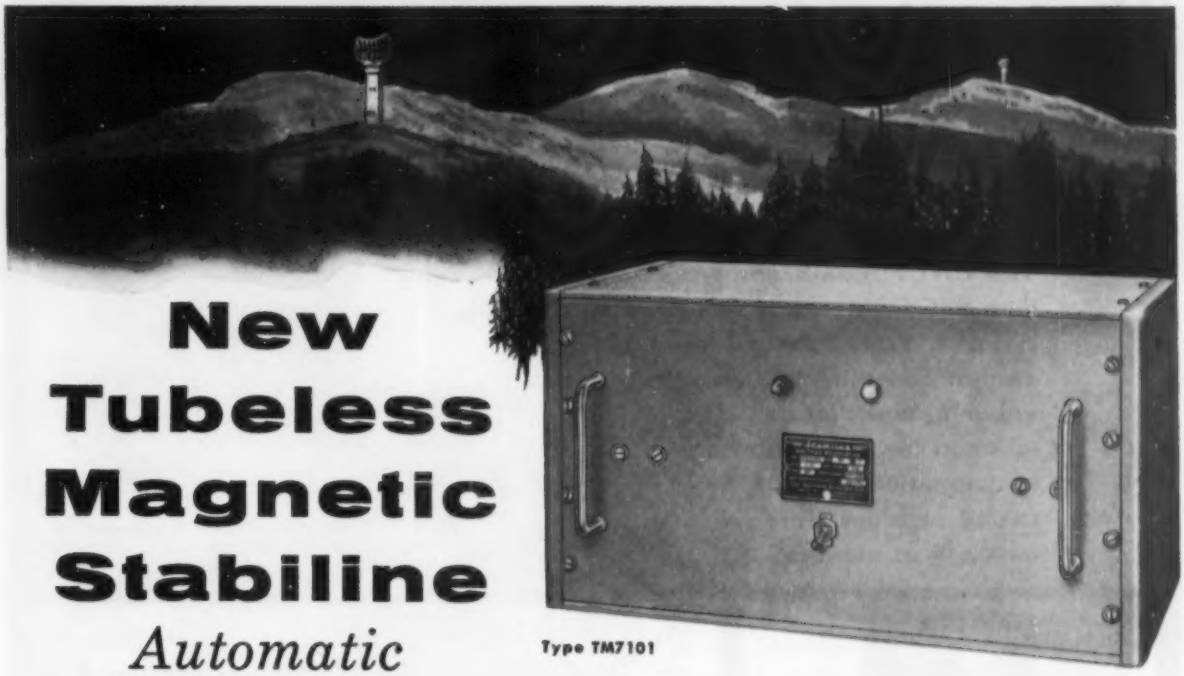
These differences alone can make *all* the difference in your operating record. But when you add them to Scovill's unequaled Technical Application Services, you have a combination you can't afford to pass up. Ask us to prove it.

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

SCOVILL **HEAT EXCHANGER TUBE**

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

14SC55



New Tubeless Magnetic Stabiline *Automatic* Voltage Regulators

Type TM7101

- *No tubes to replace*
- *No electromechanical parts to wear out*

STABILINE Automatic Voltage Regulators Type TM are the newest addition to Superior Electric's complete line of voltage control apparatus. Without tubes or moving parts it provides constant voltage regardless of line voltage or load changes. Where failure at any time under the most adverse operating conditions cannot be tolerated or where service is not a possibility over long periods of time STABILINE Type TM is a necessity. Both cabinet and rack models are offered. Send coupon below for full information.

FOR UNATTENDED LOCATIONS:
- Microwave relay stations
- Remote installations

FOR CRITICAL APPLICATIONS:
- Where sudden need for tube replacement can be costly (at a critical time in a process) or impossible (at an unattended location)
- Where conditions cannot tolerate moving parts

STABILINE Type TM7101 shown is rated:
1. Input — 95 to 135 volts
2. Output — nominal 115 volts can be adjusted from 110 to 120 volts
3. Output held within 1 volt band
4. Frequency range — 55 to 65 cycles
5. Waveform distortion — 3% maximum
6. Speed of response — less than 1.0 second for full range correction
7. Maximum load — 1.0 KVA.
8. Load power factor range — .5 lagging to unity

See Superior Electric's Mobile Display when it visits your area.

THE SUPERIOR ELECTRIC COMPANY
BRISTOL, CONNECTICUT

SALES OFFICES: The Superior Electric Company

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Fred H. Haight Co., 3212 Eastlake, Seattle 2, Wash.

THE SUPERIOR ELECTRIC COMPANY, 1311 Reynolds Ave., Bristol, Conn.

Please send me full information on the new STABILINE Automatic Voltage Regulator Type TM (Tubeless Magnetic)

Name.....

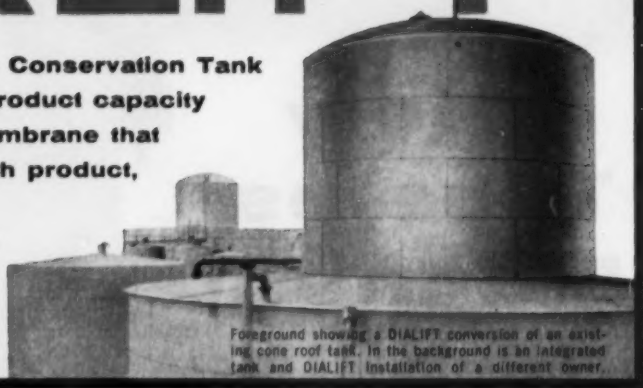
Company.....

Address.....

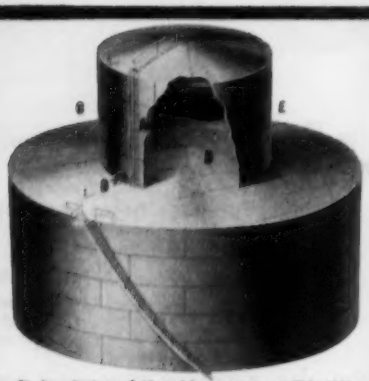
City.....Zone.....State.....

The HAMMOND DIALIFT

The ONLY membrane type Conservation Tank with full-rated vapor and product capacity AT ALL TIMES, with a membrane that cannot come in contact with product, vapor space that can be isolated for inspection and maintenance without taking product storage tank out of service.



Foreground showing a DIALIFT conversion of an existing cone roof tank. In the background is an integrated tank and DIALIFT installation of a different owner.



Principle of the Hammond Dialift

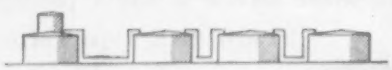
A— DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.
B— Vapor passes to and from tank and DIALIFT through simple elbow connection.
C— DIALIFT and tank have full-rated capacity.
D— Membrane can't come in contact with product.
E— DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

The most efficient and economical vapor conservation system for new or old tanks.

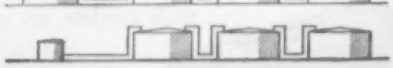
THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation: —Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a product tank for vapor conservation for one or a number of tanks.

The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.



DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.



THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

Write for catalog 55DL

HAMMOND IRON WORKS

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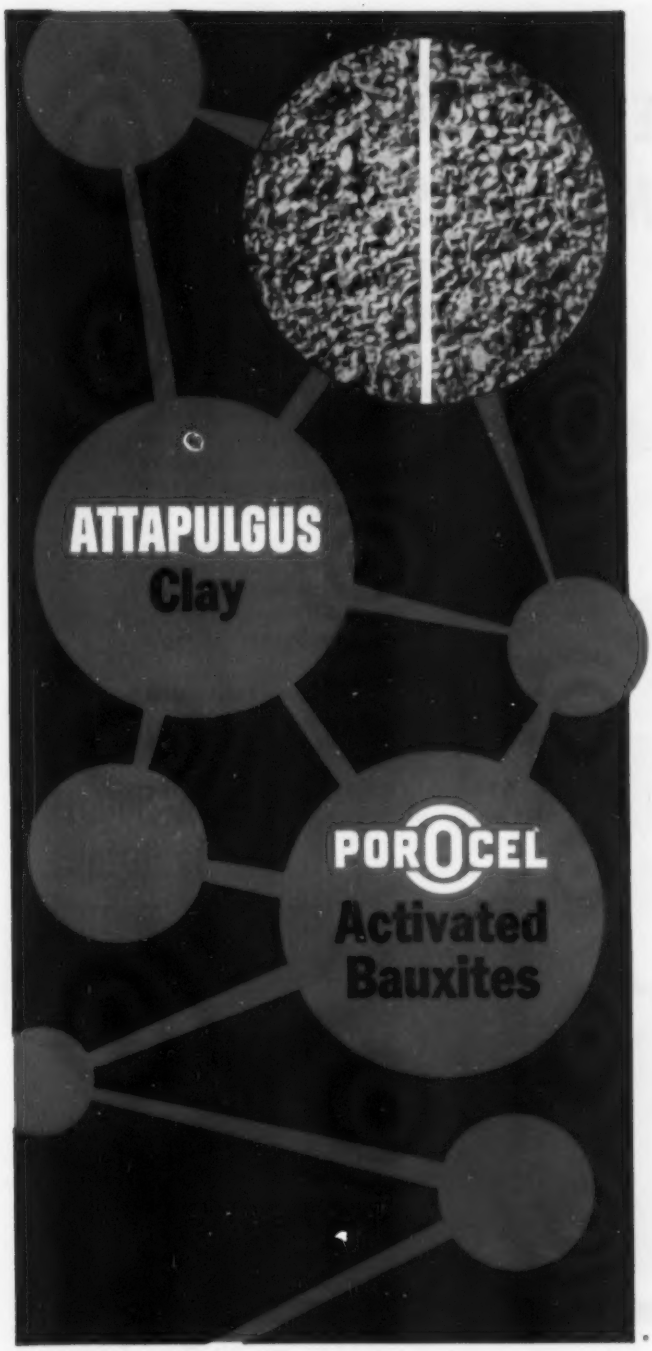


Here's the way to tackle a sorptive-mineral job

Away up in number two slot in a list of nearly 2,000 different chemicals used in petroleum refining operations is *sorptive minerals*. And the adsorbents recognized as standards in the industry are Minerals & Chemicals products—Attapulgus Clay . . . Porocel Activated Bauxites. That means there's a *headquarters* to turn to!

Want To Purify By Adsorption? There's an M&C adsorbent to fit your process scheme for removing odors, colors, taste, moisture, acids, sulfur compounds, fluorides and unsaturates from process liquids or gases.

Catalyst Carrier? M&C sorptive minerals are of highest importance in a wide variety of hydrocarbon conversion and sweetening processes.

What Do You Want To Dry? M&C offers a complete line of reliable desiccants for drying air, hydrogen, CO_2, hydrocarbon liquids and gases.

HERE'S THE NEWEST APPLICATION *of sorptive minerals in the petroleum field. Mail the coupon for your free copy of "Preparation of Petroleum Feeds for Platinum Catalysts"—and for other assistance if desired.*

ATTAPULGUS *and* **POROCEL PRODUCTS** *from*

MINERALS & CHEMICALS CORPORATION OF AMERICA
210 W. WASHINGTON SQUARE, PHILADELPHIA 5, PA.

ALWAYS A BETTER WAY . . .

MINERALS & CHEMICALS CORPORATION OF AMERICA
Dept. D, 210 W. Washington Square, Philadelphia 5, Pa.

☐ Please send me "Preparation of Petroleum Feeds For Platinum Catalysts."

☐ Please provide technical help (and samples) on the following proposed applications: _____

_____

name _____ title _____

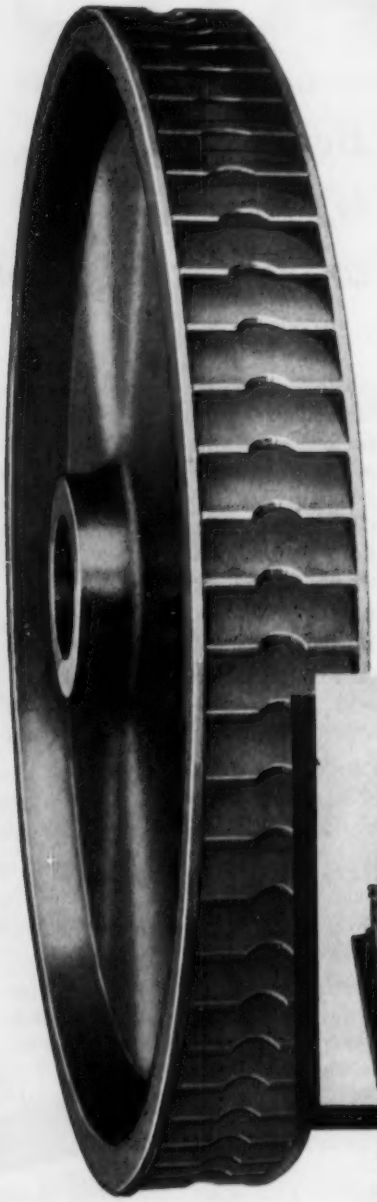
company _____

address _____

city _____ zone _____ state _____

For more data on advertised products, use Readers' Service Cards, last page.

TERRY SOLID-WHEEL *SIMPLICITY* MEANS *SUSTAINED* HP



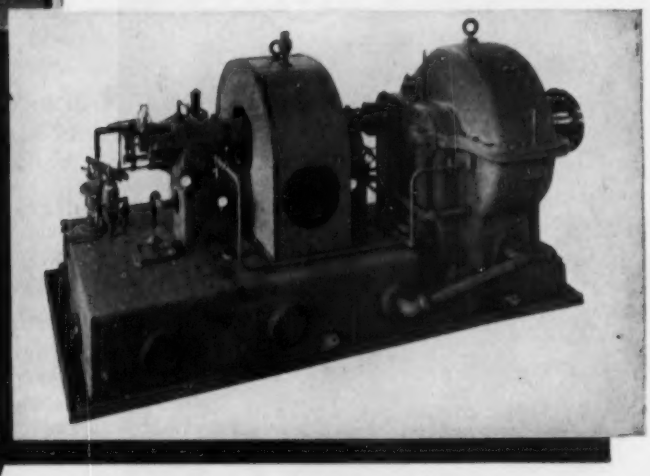
A Terry solid-wheel turbine is simplicity itself. Particularly the rotor. This is a single forging of special composition steel. And, unlike a built-up wheel, has no separate parts to loosen or work out.

Blade wear which might occur after years and years of usage is of little consequence, because the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets. Thus wear does not materially affect horsepower or efficiency.

The blades can't foul. There is a one inch clearance on either side of the wheel and, in addition, the blades are double rim protected. There is no need for close axial blade clearance, because the steam enters the buckets at right angles to the shaft.

Perhaps you, too, can profit from Terry solid-wheel stamina. Bulletin S-116 gives complete details. Send for a copy today.

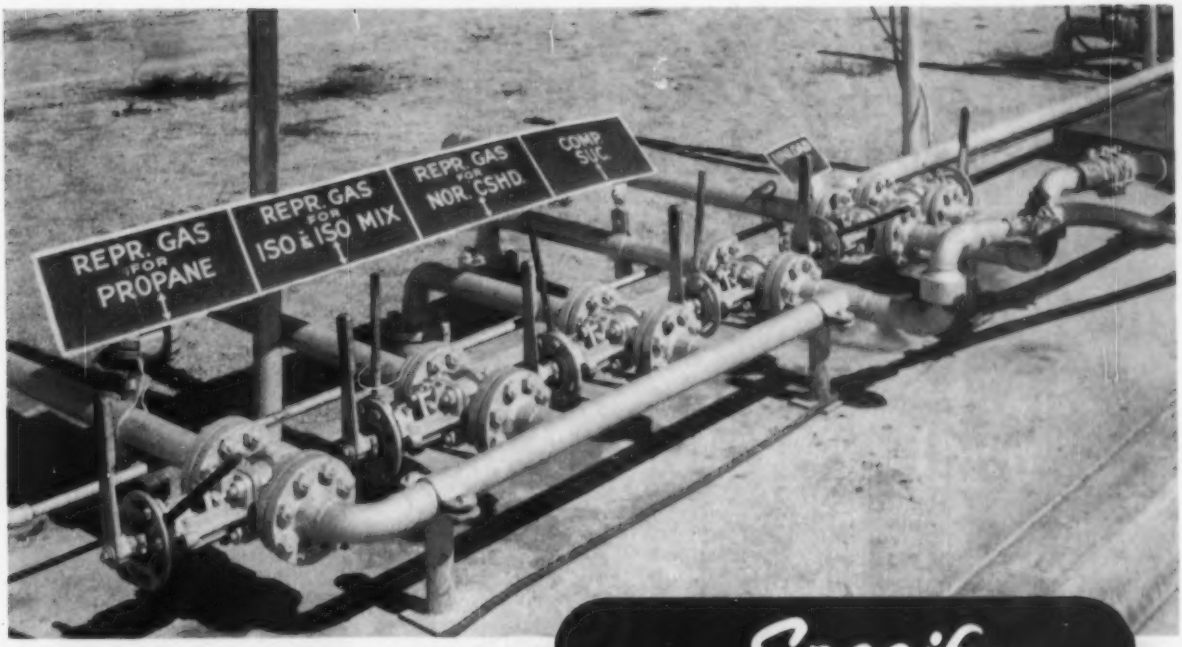
TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONNECTICUT



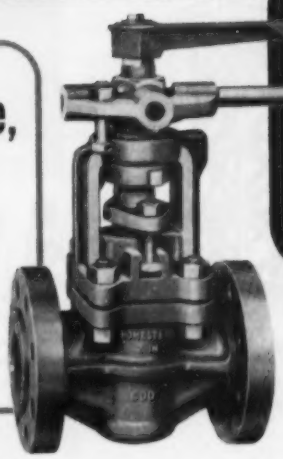
This Terry solid-wheel turbo-geared unit is rated 600 hp, 4000/650 rpm for 820 psi, 825°F steam with 275 psi back pressure.

TERRY

TT-1201



for dependable, trouble-free control of "hard-to-hold" fluids . . .



Specify HOMESTEAD Lever-Seald VALVES

they provide sure shut-off...

ARE STICK PROOF...OPERATE INSTANTLY

A positive, drop-tight seal and instant, stick-proof operation under all fluid, temperature or pressure conditions, is assured by the exclusive, built-in, Homestead Lever-Seald mechanism. This powerful lever-and-screw device not only presses the valve's tapered plug firmly into its seat to form a drop-tight seal, but also provides a positive means of relieving seating pressure just enough to overcome friction and permit easy operation. And because all operating parts and valve seating surfaces are fully protected in both the open and closed positions from the corrosive or erosive effects of line fluids, long, dependable, trouble-free service is doubly assured.

If "hard-to-handle" fluids are your problem, specify Homestead Lever-Seald Valves for your next installation or as replacements. You'll be glad you did.

We make them in metals and alloys to specification in sizes 1½" to 12", for pressures from vacuum to 1500 lbs., and for temperatures from 40° below zero to 1100°F. Dry seat, or pressure gun lubricated optional.

For complete details and copy of VALVE REFERENCE BOOK No. 39-3, MAIL THE COUPON TODAY.

HOMESTEAD
VALVE MANUFACTURING COMPANY
"Serving Since 1892"
P.O. BOX 45 CORAOPOLIS, PA.

Without obligation, send me Catalog 39-3 covering Homestead Lever-Seald Valves.

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COMPANY _____
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CITY _____ STATE _____

OFFERING *Complete* PETROLEUM REFINERY AND CHEMICAL PLANT DESIGN AND CONSTRUCTION SERVICES . . . .

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TRECO DESIGNS, ENGINEERS AND CONSTRUCTS

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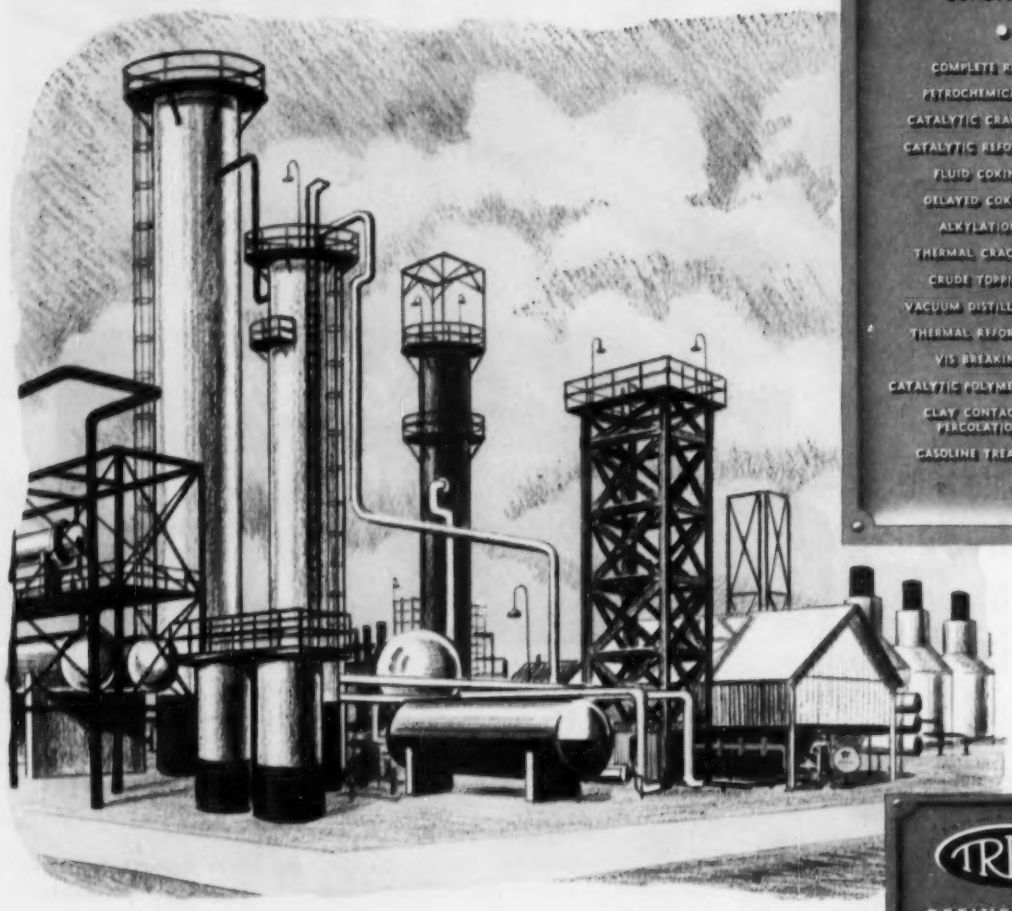

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Over the years, we have repeatedly demonstrated our ability to efficiently serve our customers on their consulting, estimating, design and construction problems. Our experience enables us to complete a project, well-engineered, and on schedule, at a minimum cost.

Nearly all former customers have complimented us by giving us additional contracts.

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REFINERY ENGINEERING *Company*

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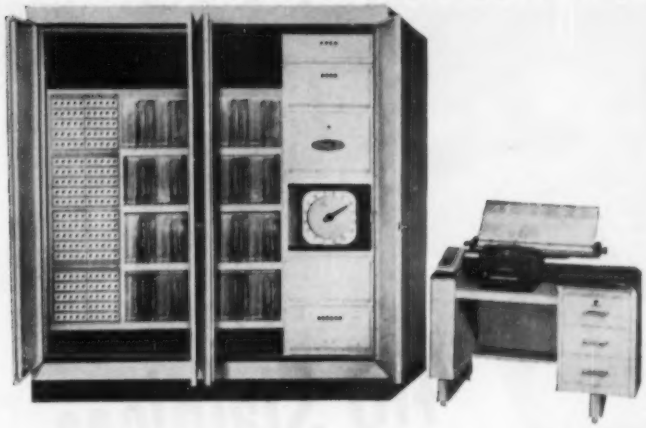
MANAGEMENT TOOL FOR GREATER PROFITS

New Dual-Function* PANALOG 605



Panalog 605 is a pre-engineered, *packaged* Information System that brings the process-management control loop within economic reach of all companies, large or small.

The Panellit Information System enables both the process operator and management to make profitable control decisions based on processed information of the moment, rather than on past historical records requiring interpretation. It opens the way for immediate as well as long-term profits that are well worth your investigation.

*periodically logs...

Panalog 605 quantizes and logs process information, periodically and on-demand. Related information groupings minimize interpretation, enabling operator and management to work with information that is well organized for immediate control use.

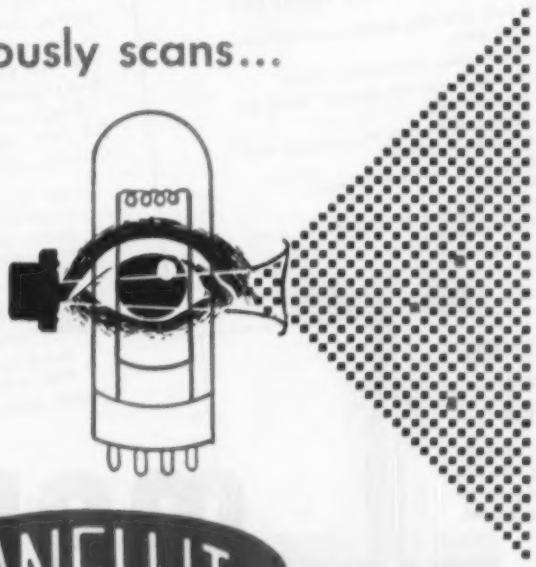
		PLANT							NO. 8 UNIT			NO. 7 UNIT			NO. 6 UNIT – NO. 15 BOILER												NO. 5 UNIT – NO. 13 BOILER												
		GEN. NET	GAS FLOW	EFF., NET					GEN. NET	GAS FLOW	EFF., NET	GEN. NET	GAS FLOW	EFF., NET	GEN. NET	GAS FLOW	EFF., NET	CONDENSER B.P.	A.H.T.O.	C.A.P.	COOL. OIL	H_2 COOL. GAS	CONDENSER COND.	GLAND STEAM			GEN. NET	GAS FLOW	EFF., NET	CONDENSER B.P.	A.H.T.O.	C.A.P.	COOL. OIL	H_2 COOL. GAS	CONDENSER COND.	GLAND STEAM			GEN. NET
T R E N D	T I M E	MWH	M BTU	BTU PER KWH					MWH	M BTU	BTU PER KWH	MWH	M BTU	BTU PER KWH	MWH	M BTU	BTU PER KWH	IN HG		PSI	°F	°F	M MHO	PSI			MWH	M BTU	BTU PER KWH	IN HG		PSI	°F	°F	M MHO	PSI			MWH
			X10	X100					X10	X100			X100			X100	$X\frac{1}{000}$		$X\frac{1}{10}$			$X\frac{1}{000}$	$X\frac{1}{10}$				X100	$X\frac{1}{000}$		$X\frac{1}{10}$			$X\frac{1}{000}$	$X\frac{1}{10}$			$X\frac{1}{10}$
T		A1	A2	A3	A4	A5	A6		A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38	A39
T	0700A	351	432	123					135	177	131	086	106	123	417	467	112	213	104	091	104	095	252	213			372	432	116	193	119	084	104	096	141	237			
T	0800A	360	443	123					138	179	130	090	110	122	420	467	111	200	106	092	104	095	250	210			380	434	114	192	114	082	104	096	142	238			
T	0832A	365	445	122					140	182	130	092	112	122	425	472	111	205	113	094	108	094	201	214			385	443	115	184	113	085	104	096	138	234			

U.S. Pat. 2,701,748

*continuously scans...

Continuous high-speed electronic scanning provides immediate audio-visual signals and readout of off-normal occurrences in a separate log section. Off-normal readout is red only on occurrence; black on return to normal. Advance indication of trouble is possible because of individual high and low off-normal settings.

Panalog 605 circuit assemblies and components are standardized, packaged modules ... permitting the system to be expanded or modified with ease. Flexible programming permits the integration of Panalog 605 into any conceivable management control system using digital information. *Write or wire for complete information.*



PANELLIT

PANELLIT, INC.

7415 N. Hamlin Ave., Skokie, Illinois

In Canada: Panellit of Canada, Ltd., 60 Newcastle Street, Toronto 14

Now the finest of needle valves is available

416 Stainless throughout...

In the Marsh Needle Valve, operating men found a valve that was better all the way through. Then came the call for a valve of like quality and precision for corrosion service . . . to be 416 stainless steel throughout.

The valve illustrated here is the answer. Like the parent valve, this new valve has safety and strength to spare . . . guaranteed for working pressures up to 10,000 psi . . . equally efficient and effective in any lower pressure range.

It too is machined from solid bar stock—in this case, 416 stainless steel. Its precision-ground and-machined stem is hardened 416 stainless. Packing is the special "Marpak" ring . . . one-piece, non-binding, long-lasting. So finely built is this needle throttling and cut-off valve that it can be easily throttled down to exceptionally fine regulation even on extreme pressure.

Read the list of features opposite. Then write for new bulletin No. NV-2 containing complete details.

416 Stainless Steel
...all the way through!

- Body and stem guide machined from bar stock.
- Valve stem, hardened stainless.
- Packing, special Marsh "Marpak" moulded ring.
- Fine stem threads for strength and precision throttling.
- Deep inlet and outlet thread chambers.
- Bodies marked in accordance with MSS regulations.

The new all stainless valves (Series 1924) includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾", 1"; also globe and angle valves with male inlet and female outlet in sizes ¼" and ½".

MARSH INSTRUMENT CO. Dept. R, Skokie, Ill.
Sales affiliate of Jas. P. Marsh Corp.

Marsh Instrument & Valve Co. (Canada) Ltd.
8407 103rd Street, Edmonton, Alberta, Canada

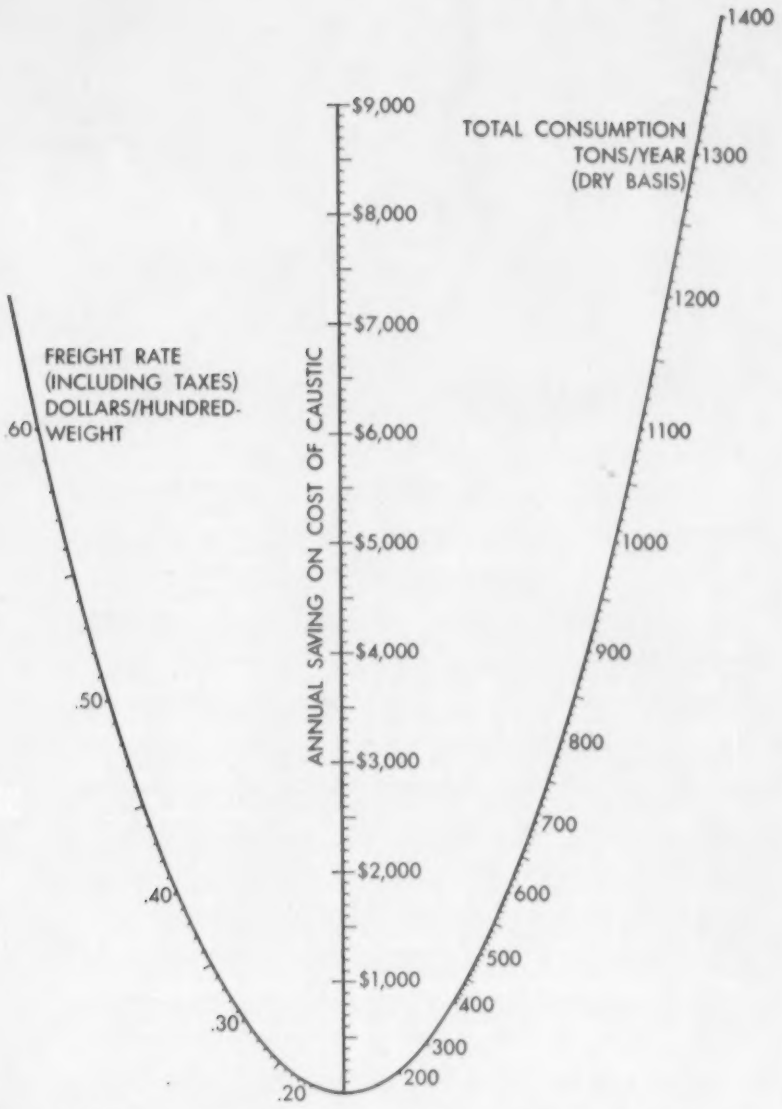
HOUSTON BRANCH PLANT: 1121 Rothwell Street, Sect. 15, Houston, Texas

Maximum Working Pressure 10,000 P.S.I.

Water, oil, gas or corrosive fluids not injurious to 416 stainless steel.

MARSH

"THE STANDARD of ACCURACY"



Which saves you more...

50% or 73% Caustic Soda?

This nomograph can help you decide Are you using the caustic solution that's least expensive for you? A few seconds' calculation with this nomograph will help you decide.

How to find if you can save on 73% caustic soda Simply draw a line from your freight rate (including taxes) to your annual consumption in tons on a dry basis. Your approximate savings will appear where this line intersects the center line of the nomograph.

This figure represents your savings on freight charges after the $2.00 premium price on 73% caustic soda has been deducted.

From this figure you must deduct a depreciation charge based on the cost of dilution equipment. Your Hooker technical service man is ready to advise you on the equipment needed and its cost.

Double-check your findings this way Before you make a final decision on 50% or 73%, give yourself the advantage of expert technical advice. Let your Hooker technical service man show you what equipment you will need for 73%. He will figure your exact savings—based on a realistic study of your operations.

For quick service, write or phone the nearest Hooker office.

"CAUSTIC SODA BUYER'S GUIDE" is the title of a new pocket-size booklet we'll be glad to send you free. Contains helpful facts on the economics of 50% and 73% solutions; other forms of caustic soda; capacities of tank cars and other containers; useful shipping information. Write us for a copy.

HOOKER CHEMICALS

1905—Half a Century of Chemicals
From the Salt of the Earth—1955

HOOKER ELECTROCHEMICAL COMPANY

52 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

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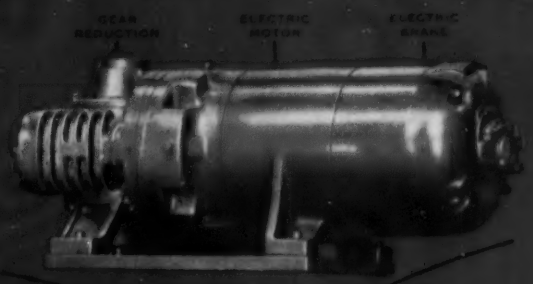
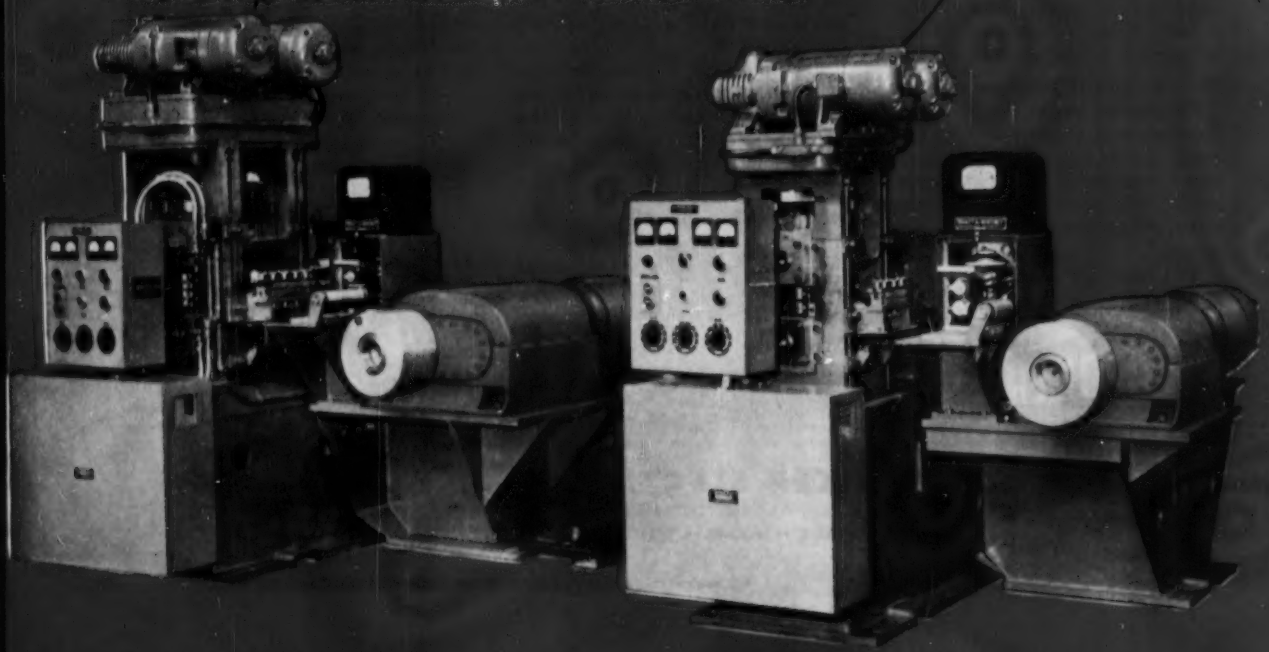


See how easily the standard electric motor, standard gear reduction, standard electric brake combine into a drive that gives the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features . . . all in one compact unit. Nowhere else will you find power units that are so flexible, so easily adaptable, and in such a wide range of types and ratings.

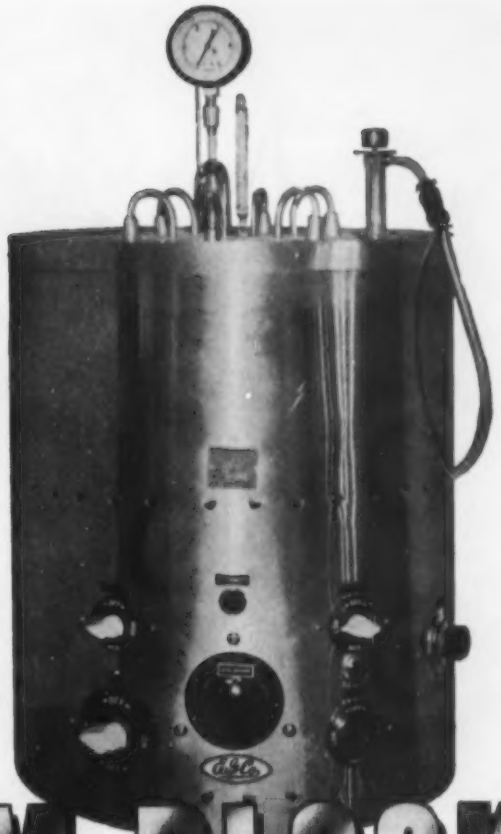
Master power drives are available in thousands and thousands of ratings (⅛ to 400 HP) . . . in open, enclosed, splash proof, fan cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 430 to 1 ratio . . . with electric brakes . . . with fluid-drive . . . with mechanical or electronic variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best power drive for you.

standard units easily combine into special purpose drives

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



for
determining
existent gums in
aviation gasoline...
motor gasoline...
jet fuels



ALUMINUM BLOCK
gum apparatus

WITH BUILT-IN STEAM SUPERHEATER ASTM D381-52T... VVL791E METHOD 3302.3

This aluminum block constant temperature bath is suitable for determining existent gum in aviation and motor gasoline using air preheated to a temperature of 320° F or for jet fuels using steam as the vaporizing medium at a superheated steam temperature of 450° F.

The apparatus consists essentially of a solid aluminum block. The coils for the vaporizing medium are completely embedded in the aluminum and properly manifolded to permit equal distribution of air or steam to each jet outlet at the prescribed rate of flow of 1,000 ml. per second.

A dial type flow meter gauge is provided for convenient reading. The heaters are of the high temperature sheath type and of sufficient wattage and arrangement to insure a uniform heat distribution over the entire block. The controlled heating system consists of one bank of heaters operating from a three-heat switch . . . also a variable heater controlled by an Auto-Transformer (Powerstat). The intermittent heater circuit also operates from a three-heat switch in conjunction with a sensitive thermo regulator and mercury type relay. Built into the lower control compartment is an electrically heated steam superheater operating from a three-heat switch and temperature controlled by means of an hydraulic type sensitive regulator. This built-in feature eliminates the need of any outside superheater installation.

PRICE

G18410 Aluminum Block Gum Apparatus, 6 unit model complete with 6 beakers, thermometers, flow gauge and built-in steam superheater. Size approximately 18" diameter by 26" high. **Ea. $1,350.00**

Send for "Labitems" describing Aluminum Block Gum Apparatus and other new petroleum testing instruments.

E&C Co. 75 years 1880-1955

20-26 NORTH MOORE ST. • DEPT. 235 • N. Y. 13, N. Y. E&C Co. **The EMIL GREINER Co.**

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"Million-dollar chunk of steel" being floated to offshore position, where it will be settled on the bottom by filling the pontoons with water

Sheffield Steel products "go to sea" in history's biggest treasure hunt

Talk about sunken treasure! Under the coastal waters of Texas and Louisiana lie oil pools estimated at nearly half the total of recoverable reserves in the U. S.

Sheffield was ready when the Tidelands Bill gave the treasure hunt signal. Ready with steel for building the drilling platforms – man-made "islands" as far as 30 miles at sea. Ready with bolt and nut products; high-strength structural bolts; structural steel and merchant shapes; plates for barges and pontoons; and numerous other steel items which implement the big search for new oil.

Big as it is already, offshore oil production is barely out of the pioneering stage. Its future is tremendous. Sheffield is geared to produce the steel that's needed. If you're in any part of the oil business, you have an interest in knowing how Sheffield quality steel and Sheffield's strategic location provide important advantages. Get the facts from your nearest Sheffield office.

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Quality Steel for the oil industry

SHEFFIELD STEEL

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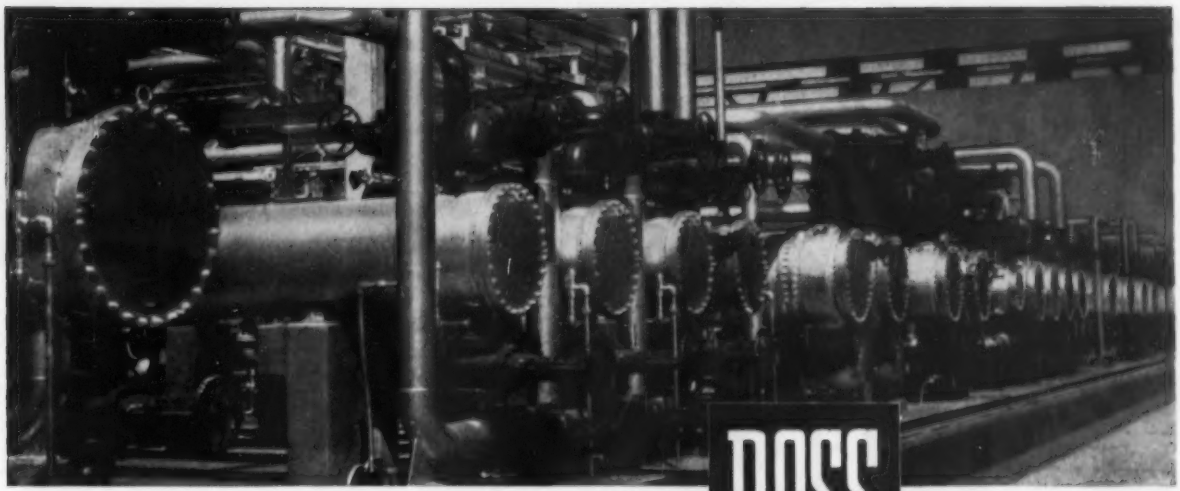
HEAT EXCHANGERS BY THE MILE



ROSS

If you watch production at the Kewanee-Ross plants, you'll see the world's most modern heat exchanger assembly techniques at work . . . moving exchangers and condensers down the lines by the thousands . . . to serve industries here and abroad.

Complex, highly specialized, refinery exchangers and giant power plant surface condensers . . . one of a kind or dozens alike. Completely standardized engine oil and water coolers, compressor inter and after coolers, hydraulic fluid coolers . . . hundreds upon hundreds of identical units. End-to-end, they would stretch out for miles.

Standardized or specialized, mammoth or pocket size, single or by the thousand . . . whatever industries require in heat exchangers, Kewanee-Ross makes it. In its long, diversified experience, this Company has engineered and built virtually everything that is sound and practical in heat transfer equipment.

Where can you find a more qualified source for serving *your* requirements? Who could possibly be in a better position to work with you . . . to recommend and *deliver* exactly what you need? Your request will bring a Kewanee-Ross engineer promptly to your desk. Write.

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DIVISION OF AMERICAN RADIATOR & STANDARD SANITARY CORPORATION

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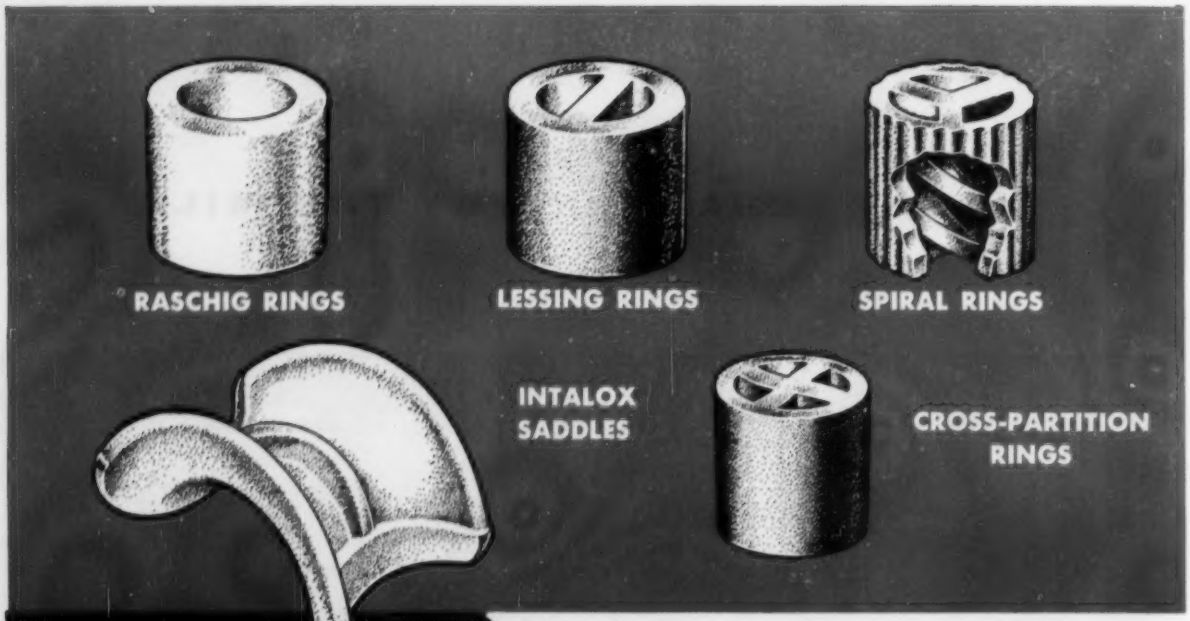


TOWER PACKING

U. S. Stoneware offers a range of types and sizes of Tower Packings not even remotely approached by any other manufacturer . . .

INTALOX SADDLES
Unique design minimizes "pattern" packing, blocking, or nesting in dumped beds. Appreciably greater surface area. Lower pressure drop. Higher flooding limits. Made in ½" ¾", 1", 1½" and 2" sizes in both high-fired chemical porcelain and chemical stoneware.

RASCHIG RINGS
Low initial cost. Most widely used of all tower packings. Made in chemical porcelain, chemical stoneware, carbon, steel and other alloys. Size range from ¼" to as high as 6", depending upon material. Sizes up to 2" are generally dumped. Larger sizes, stacked.

LESSING RINGS
A modification of the Raschig Ring. The ring has a single partition or web added to the inside. Made in 1", 1¼", 1½" and 2" sizes in chemical porcelain or chemical stoneware. Usually dumped.

CROSS-PARTITION RINGS
A further modification of the Raschig Ring. Two inside webs cross each other at right angles to create a "4-cell" ring. Cross-Partition rings are made in 3", 4" and 6" sizes in chemical stoneware. They are usually stacked in the tower.

SPIRAL RINGS
Made in single, double or triple spiral types. The function of the spirals is to increase the turbulence of the gas stream. Made in chemical stoneware in 3¼", 4" and 6" sizes. Spiral rings are used in stacked beds.

All U. S. Stoneware ceramic tower packings are made from bodies especially developed for tower service. They are extremely tough, possess high resistance to spalling and exceptional corrosion-resistant properties. Chemical porcelain bodies are completely iron-free and are of zero porosity.

CJ1-D

The U. S. STONEWARE Co.
AKRON 9, OHIO

THE RIGHT STEAM TRAP FOR LIGHT CONDENSATE LOADS

YARWAY 20-A IMPULSE STEAM TRAP

● Successful companion to the standard Series 60 YARWAY Impulse Steam Trap, the ½" No. 20-A is right and recommended for *light load* applications in:

REFINERIES, CHEMICAL AND PROCESSING PLANTS on steam tracer lines, meter boxes, steam mains, separators, small dryers, pipe coils, small unit heaters, etc.

POWER PLANTS on headers, fuel oil preheaters, compressed air lines, small steam jacketed fire pumps, etc.

HOSPITALS, SCHOOLS, HOTELS AND INSTITUTIONS on autoclaves, sterilizers, steam tables, washers, small pressure cookers, steam mains, etc.

LAUNDRIES on small presses, puff irons, sock forms, drying cabinets, starch cookers, steam mains, etc.

The 20-A has all the YARWAY Impulse Trap features such as small size, stainless steel body and working parts, low cost, non-freezing—and immediate availability through 270 local Industrial Distributors.

Write for Bulletin T-1739-X.

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY® IMPULSE STEAM TRAP

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

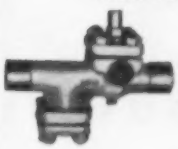
There's a Yarway Impulse Trap for every trapping need

SERIES 60 AND 120
For all *normal* trap requirements, pressures to 400 and 600 psi.

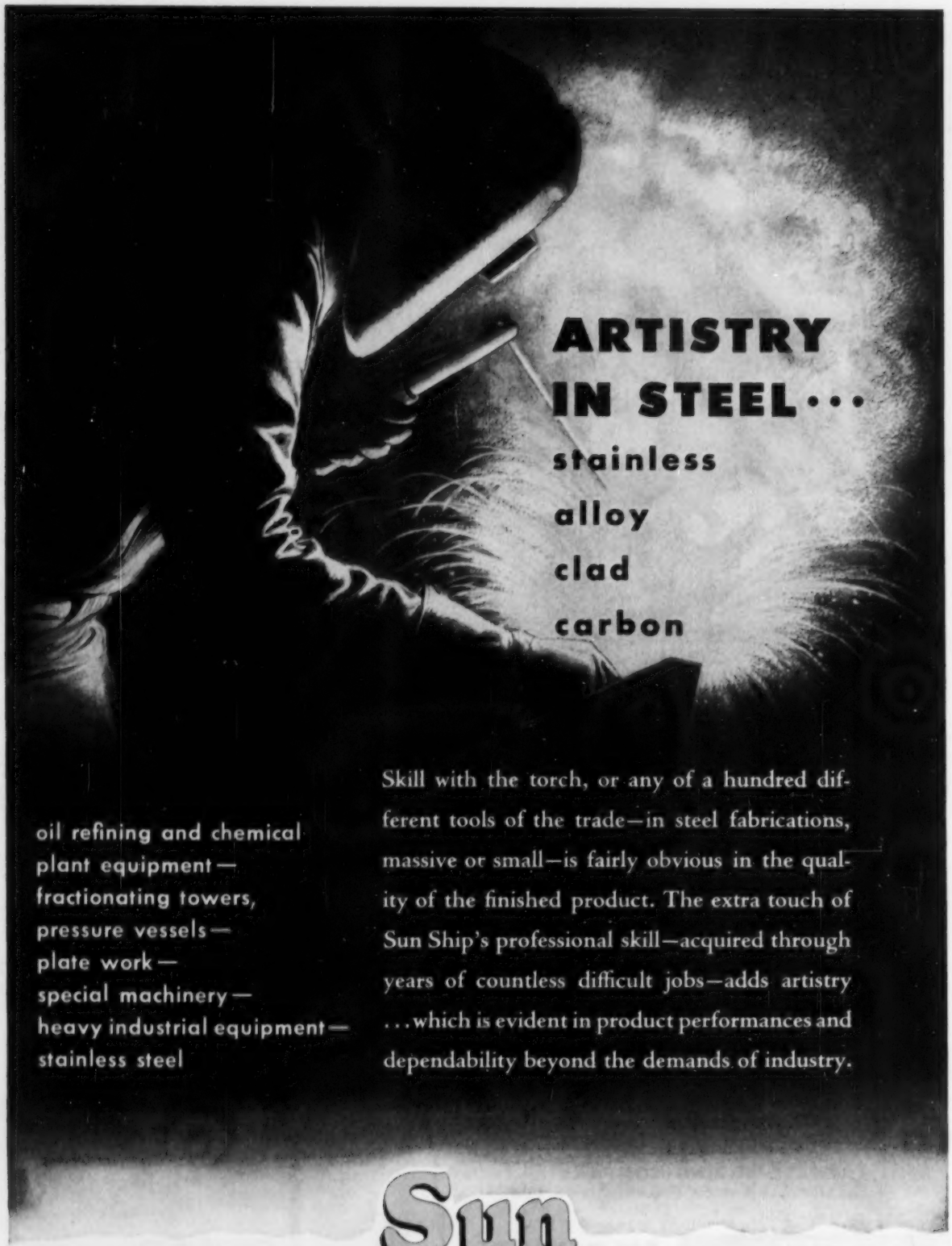
½" No. 20-A
For *light loads* on tracer lines, steam mains, small presses, etc.

SERIES 40
For *heavy loads* requiring extra high capacity steam traps.

INTEGRAL-STRAINER HIGH PRESSURE TRAP



For *high pressures, high temperatures.* (Flanged or welding connections.)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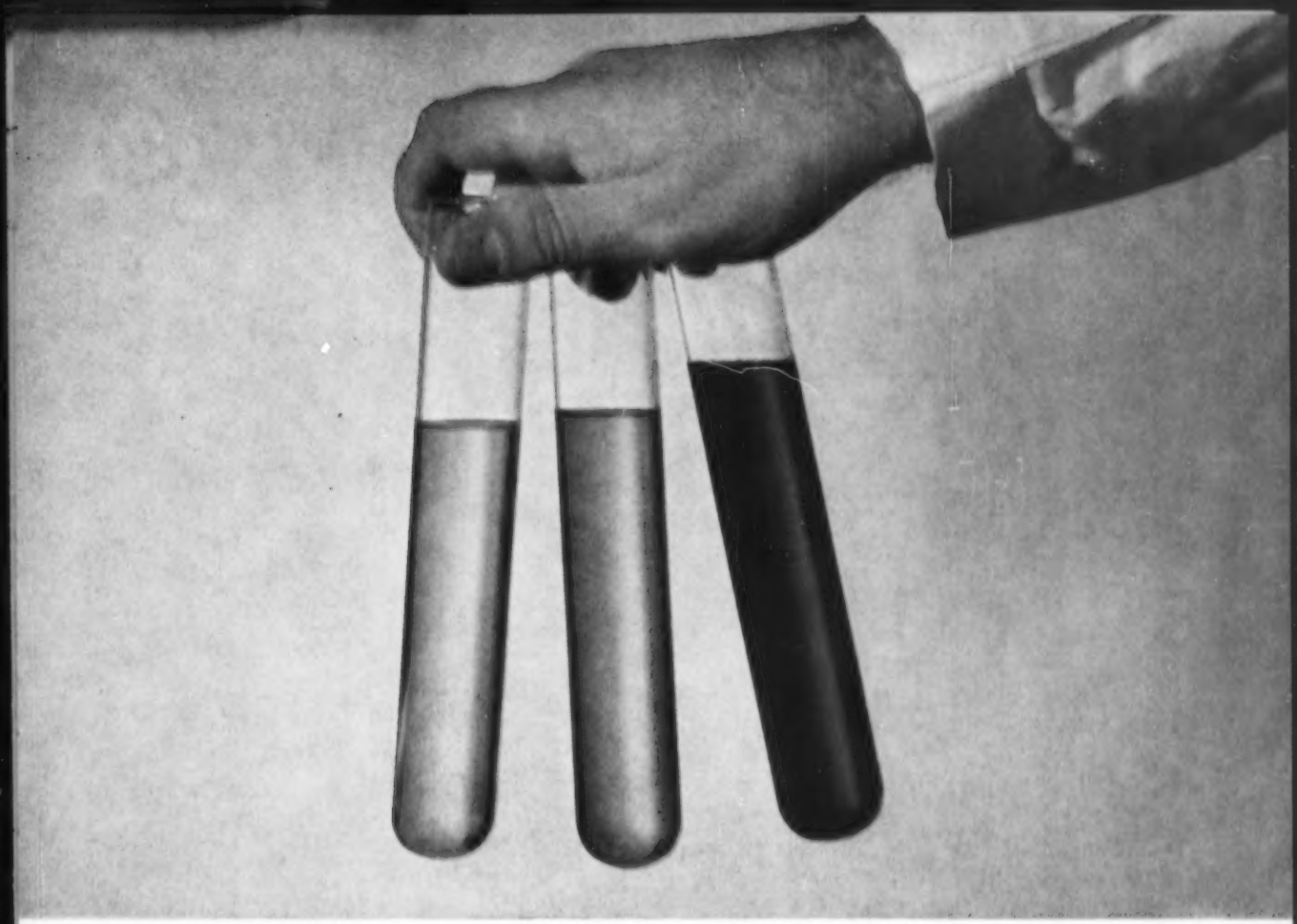

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NALCO-STABILIZED FUEL OIL STAYS CLEAR

This blended straight-run and cat-cracked fuel oil was refined in Texas. Unstabilized, it degraded to N.P.A. Color 4.0 after tanker shipment to New York and subsequent 4 months storage. How the same oil, Nalco stabilized, withstood the trip and storage is dramatically shown in the unretouched color photo, above.

At left, a refinery fresh sample has N.P.A. Color 1.5. Center, Nalco-stabilized sample has N.P.A. Color 2.0 after 4 months. Right, untreated sample has N.P.A. Color 4.0 after 4 months.

Here is real Nalco protection against color degradation . . . protection that has the bonus value of effective sludge prevention. Nalco Fuel Oil Treatment adds up to *better fuel oil salability*, regardless of fuel types, storage or handling problems. Full data are available, now. Call or write for Technical Data Sheets on Nalco stabilizers.

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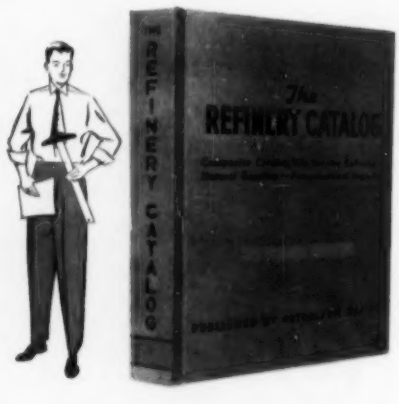
Reach for your *Refinery Catalog* whenever you're planning a project . . . you will find it the preferred source of catalog information.



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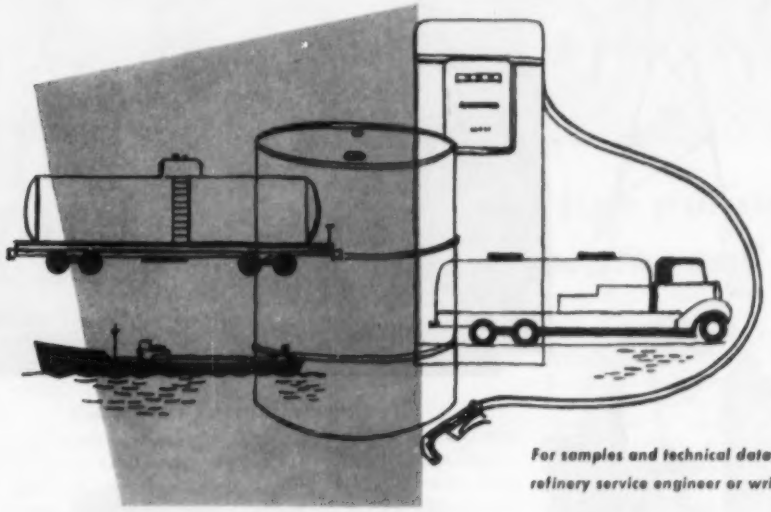
KUPLEX
METAL DEACTIVATOR

A New Tretolite Company product

Copper contamination of refined products can result from as little as 0.028 mg. of copper per gallon. Copper contamination often results from copper treating, but flow through copper or copper alloy equipment also can result in potentially harmful contamination. Further sources of contamination, pipelines, pumps, tubing and fittings can contribute to copper contamination even after the hydrocarbon product has left the refinery for distribution. Kuplex offers the refiner a method of product quality protection at a minimum cost. Kuplex nullifies, by a chelating action, the catalytic degenerative oxidation caused by copper in hydrocarbons. Especially applicable to gasoline, Kuplex is also effective in hydrocarbon streams such as kerosine, jet fuel, diesel and burning oil, turbine oil and greases.

INSURES BETTER, MORE STABLE REFINED PRODUCTS



For samples and technical data, ask your Tretolite refinery service engineer or write to

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A DIVISION OF PETROLITE CORPORATION

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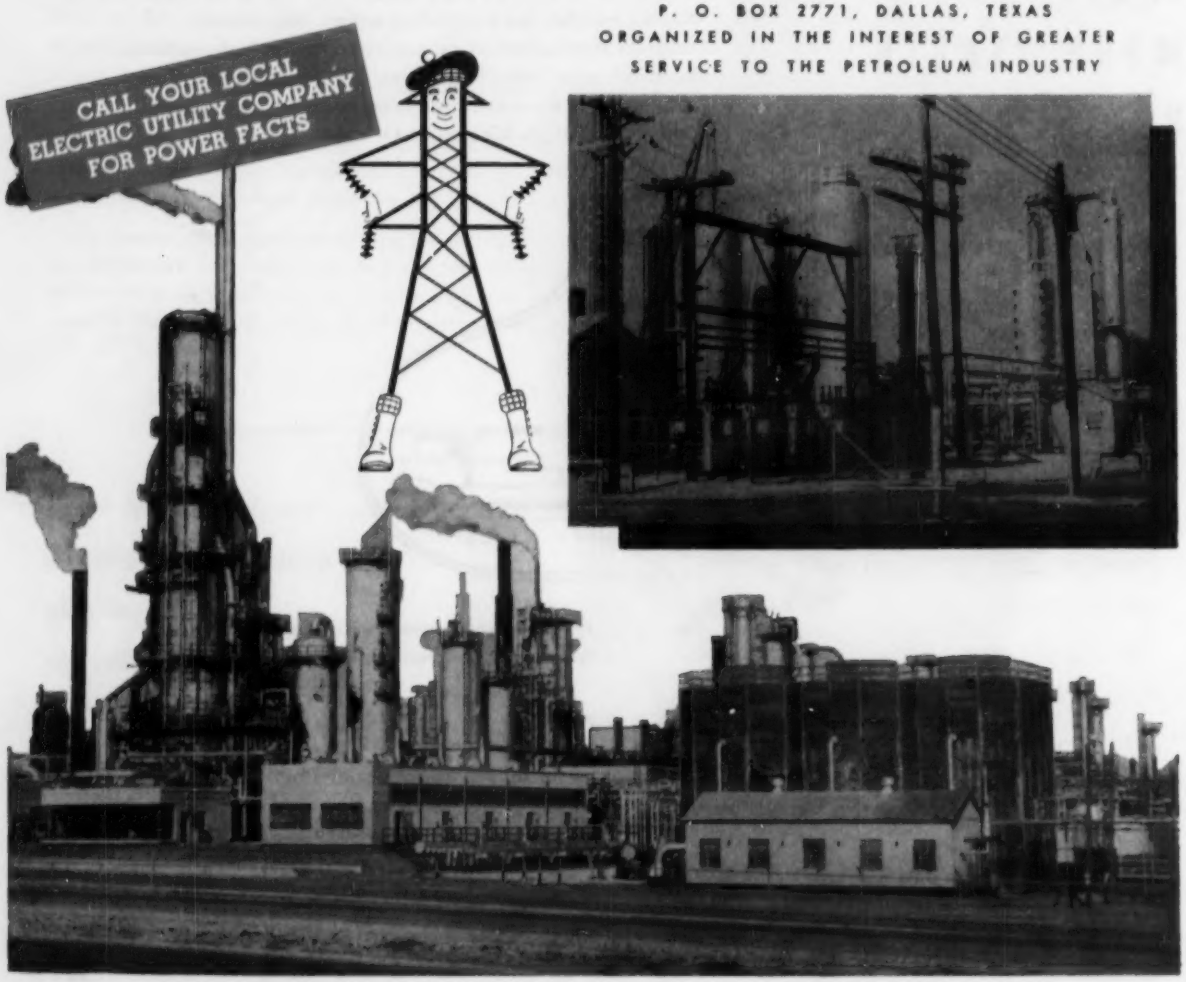

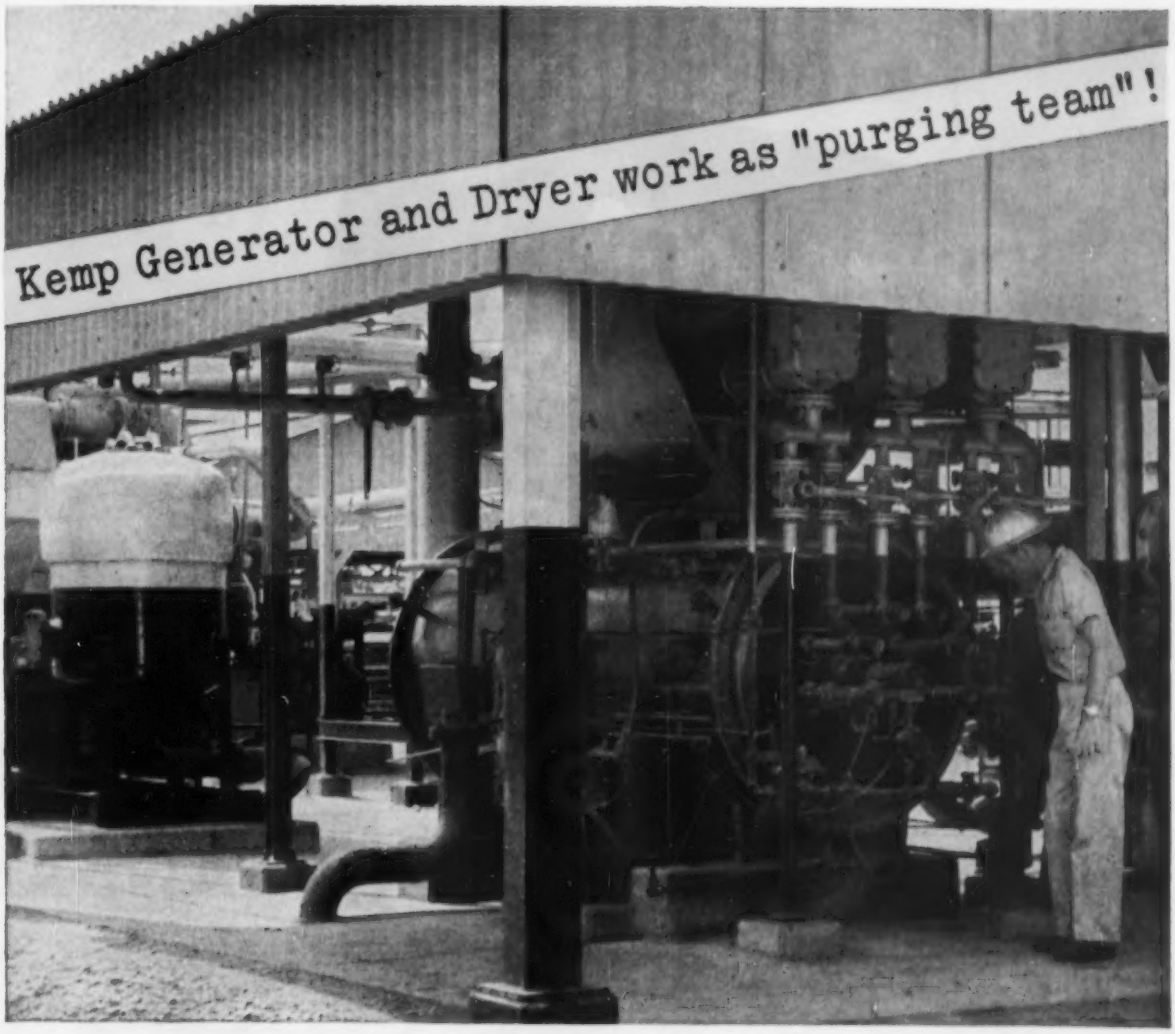

Gulf Oil Reports: *Pipe line purging problems solved by Kemp Gas Generator and Kemp Dryer*

At Gulf Oil's Port Arthur, Texas refinery, dry inert gas is required in the Ethylene Plant for purging pipe lines, tanks and vessels.

Kemp Units selected to do the job

To insure a constant supply of gas—sufficiently dry and free of oil vapors—Gulf installed both a Kemp Inert Gas Generator and a Kemp Convection Type Dryer. The units work as a "purging team"...the Kemp Generator produces 30,000 SCFH of inert gas which is compressed and passed through a Kemp Pre-filter to remove all moisture prior to entering the gas receiver. The result is an efficient, easily controlled source of dry inert gas at all times.

Kemp can solve your problem too

Whether your needs involve dry gases, inert gases—or both, Kemp can help you to the most profitable solution. Kemp Inert Gas Generators automatically deliver clean, controlled atmospheres at specific analysis, without fluctuation—regardless of demands. A variety of Kemp Dryers are designed to dry air, gases or liquids to sub-zero dew points and are available with manual, semi-automatic or fully automatic tower reactivation. In addition, Kemp will specify the proper desiccant for the job.

For complete facts and technical information on Kemp Inert Gas Generators and Kemp Dryers, write today to: The C. M. Kemp Mfg. Co., 405 East Oliver St., Baltimore 2, Maryland.

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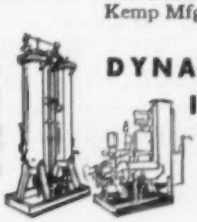

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Brown Fintube

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Important changes in OKLAHOMA, KANSAS

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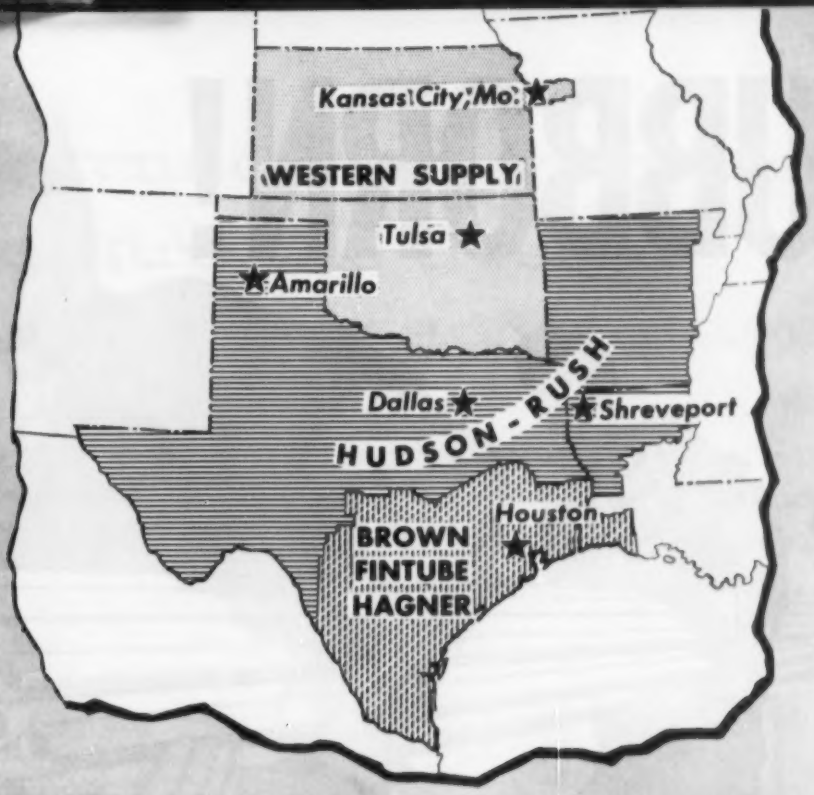
We proudly announce that the Heat Exchanger Division of Western Supply Company, under the extremely able direction of "Jim" Hughes, Vice-President, is now exclusive Sales Representative of our products in Oklahoma and Kansas, also Kansas City, Missouri, where a local telephone will be direct connected to the Tulsa Office. This appointment assures prompt and experienced assistance to our present and future customers in this important territory;— and also enables us to welcome back into the Brown Fintube family, "Ed" Anderson, who formerly was a member of our home office research and rating staff.

Robert C. "Bud" Hagner, who formerly handled our products as a manufacturers representative is now Manager of our direct factory branch office newly opened in Houston. Thus, he will now devote his entire efforts serving the heat transfer requirements of our customers and prospects in the Houston area.



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Hudson-Rush Company, with home offices in Shreveport and Dallas, who have served the needs of their territory so well, for many years, are opening a new branch office in Amarillo under the capable and experienced Wayne L. Griffiths.

With these changes and additional offices we bring the Company's long and extremely successful experience in heat transfer closer to our customers and friends, and are better able than ever before, to meet the heat transfer needs of the entire Mid-Continent and Texas area.

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STUBBORN!

Chase® Antimonial Admiralty Heat Exchanger Tubes *RESIST DEZINCIFICATION!*

Dezincification holds no fears for the users of Chase Antimonial Admiralty Heat Exchanger Tubes! For *this* special alloy can give *years* of extra service under the most corrosive conditions!

Rugged testing in Chase laboratories, plus careful manufacturing in Chase mills, team up to give Chase Antimonial Admiralty a longer, healthier life span. To you, this can mean lower operating costs, fewer breakdowns, longer waits between tube replacements.

Enjoy these benefits! Insist on Chase Antimonial Admiralty!

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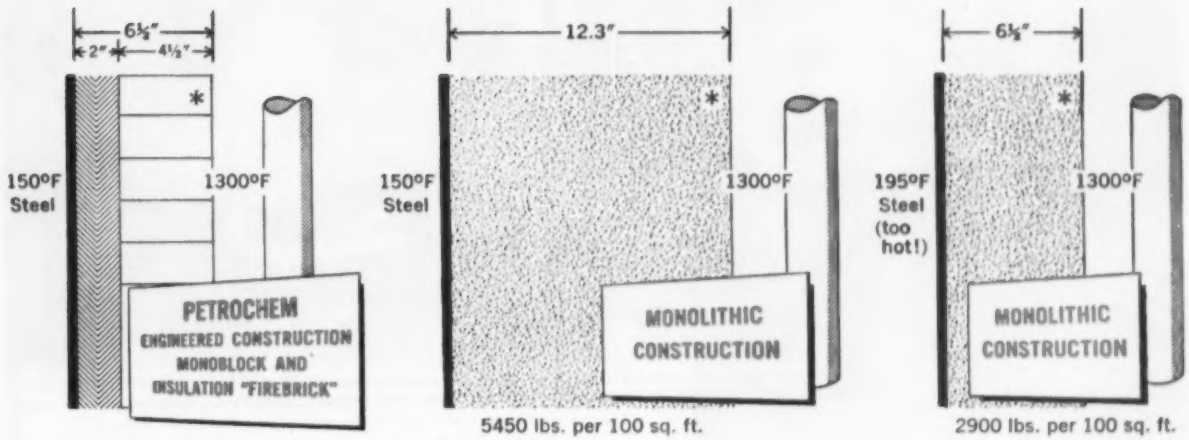
In furnaces as in processes compare the design to judge the advantages

As an example:

The wall construction of all Petrochem-Isoflow Furnaces is designed for 150°F maximum outside shell temperature.



*Based on B & W values.

The Petro-Chem design provides a thoroughly engineered wall construction. It is built with two tiers of monoblock supported on 18 inch centers and a circular arched wall of insulating firebrick. The inside of the steel shell is protected from the possibility of corrosion by a one-eighth inch thickness of Staylastic cement. This type of construction, independently supported monoblock and the circular arch of firebrick, bonded with Smoothset mortar, assures optimum efficiency and minimum maintenance.

The use of monoblock and insulating firebrick laid as a circular arch provides many advantages over a one-piece monolithic lining, including:

1—Low weight, 2—Low heat conductivity, 3—High hot crushing strength, 4—Low expansion coefficient, 5—Resilient compressible backing, 6—Long life, 7—Nil maintenance.

Also, this construction has low heat storage capacity, speeds both heating and cooling. Its light weight requires less concrete foundations and steel supports.

Compare and your judgment will affirm
Petrochem-Isoflow Furnaces are Most Efficient by any Comparison

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

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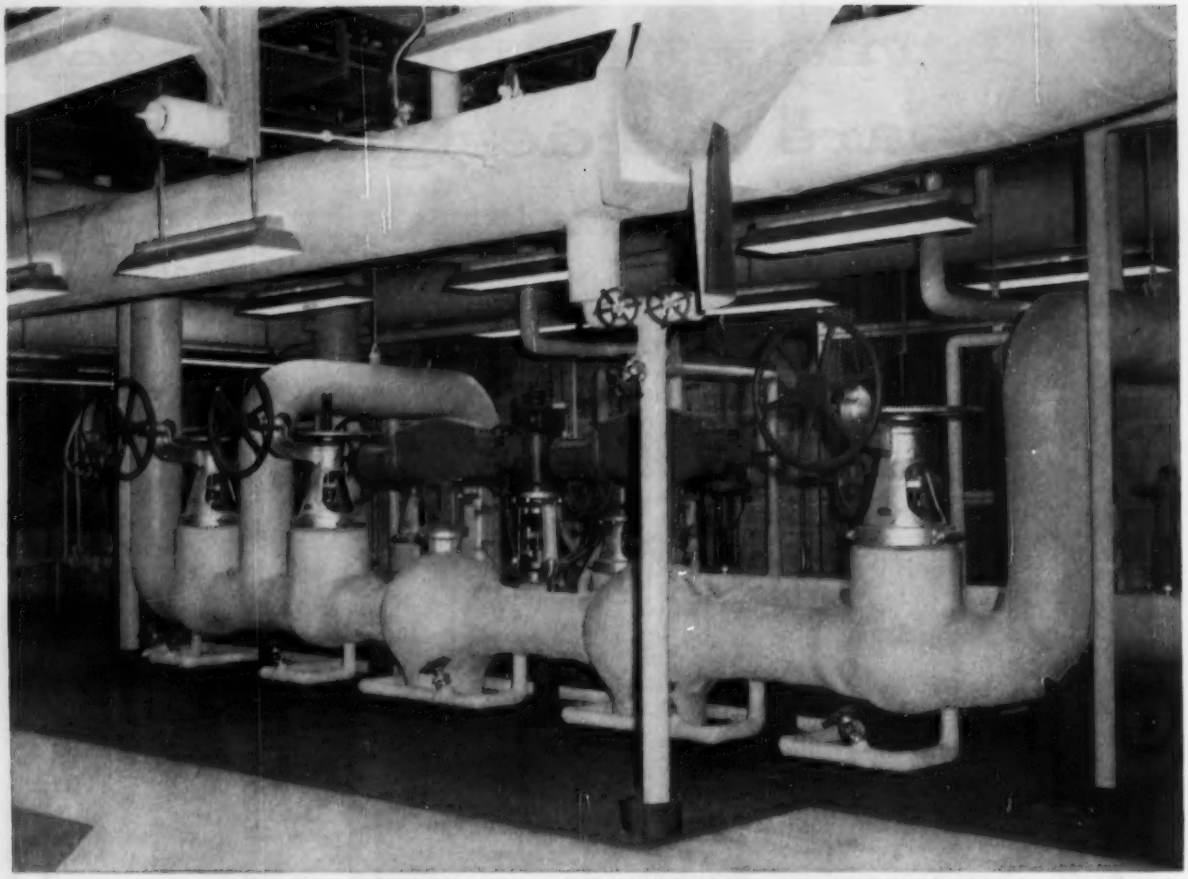
For more data on advertised products, use Readers' Service Cards, last page.



Shown are the main steam piping (above) and the boiler-feed-water flow-regulating valves (below) at Pennsylvania Power & Light Company's Martins Creek Steam Electric Station, Martins Creek, Pa.—another installation of K&M Insulations, saving heat . . . saving fuel . . . saving money.

Is your present insulation still efficient?

HIGHER TEMPERATURES CALL FOR HEAT-SAVING K&M INSULATIONS

If operating temperatures have been increased in your plant, insulations that formerly were adequate may now be costing you many dollars in heat losses every day. As fuel costs rise, heat losses become an ever-increasing expense. For important savings in fuel, heat, and dollars, install K&M high pressure insulations—acclaimed for years for efficient heat conservation.

K&M "Featherweight"® 85% Magnesia and K&M Hy-Temp Insulations last the life of the equipment they serve. They withstand moisture, vibration, frequent temperature changes. "Featherweight" efficiently insulates piping and equipment at temperatures to 600° F. For efficiency to 1900° F., Hy-Temp and "Featherweight" are applied in combination, with staggered joints. This eliminates the heat loss that normally occurs in single-layer installations when expansion causes joints to open.

Where moisture is a problem, K&M "Featherweight" Water-Resistant Magnesia Insulation is especially effective. It is used where temperatures rise to 450° F.

Check your operating temperatures, then contact your K&M distributor—an experienced applicator—for details about the heat-saving K&M insulations your plant should have. Or write directly to us.

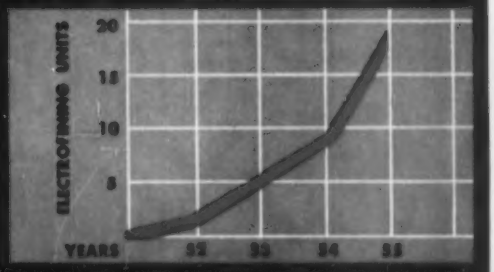
KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos®

WHY THE ACCELERATING INTEREST IN ELECTROFINING

In 1950 the first Petreco Electrofining* Unit was installed. Now there are 18 Electrofiners installed and — at the last count — six more under construction and on order.

**Petreco Electrofining is a compact, automatic, fast treating process for continuously contacting a light hydrocarbon stream with a treating agent, then rapidly separating the chemical from the treated product.*



THIS TABLE SHOWS THE WIDE ACCEPTANCE AND APPLICABILITY OF *ELECTROFINING*.

ELECTROFINING INSTALLATIONS

Refinery Location	Electrofining Treatment	Number of Units	BPD Capacity	Stock Treated
California	Acid	1	16,000	Light Pressure Distillate
California	Acid	4	8,600	Lube and Spray Oils
Indiana	Caustic	1	10,000	Blended light cycle oil and straight run naphtha
Kansas	Doctor	1	11,000	Straight run and cracked gasoline
Pennsylvania	Caustic**	1	12,500	Gasoline
Pennsylvania	Caustic**	1	3,600	Gasoline
Texas	Caustic**	2	5,000	Thermally cracked distillate
Texas	Caustic**	2	5,000	Cat distillate
Texas	Caustic**	3	30,000	Cat distillate
Texas	Acid	1	4,430	Lube Oil
Texas	Sulfonation	1	2,000	Virgin distillate
Texas	Dewatering	2	6,000	Vacuum Tower Gas Oil

**Caustic Scrub and Water Wash

Additional Electrofiners are under construction or on order for refiners in Canada, Pennsylvania, New York, Ohio, and New Jersey.

HERE ARE THE REASONS WHY MORE AND MORE REFINERS ARE SPECIFYING ELECTROFINING FOR LIGHT OIL TREATING:

1. Compact
2. Continuous
3. Precision Controlled
4. Minimum Carry-over
5. Less Treating Chemical Used
6. Eliminates Haze Stabilizers
7. Fast-Tower to Market
8. Efficient—Removes Tarry Acids, Spent Caustic, Metals, Mercaptans and other Impurities
9. Flexible—Single, Dual, Two Phase Units Available
10. Automatic—Minimum Operating Attention Required
11. Costs Less than any Comparable Process

For complete information, call or write

PETRECO®

A DIVISION OF PETROLITE CORPORATION

3202 South Wayside Drive, Houston 1, Texas

1390 East Burnett St., Long Beach 6, California

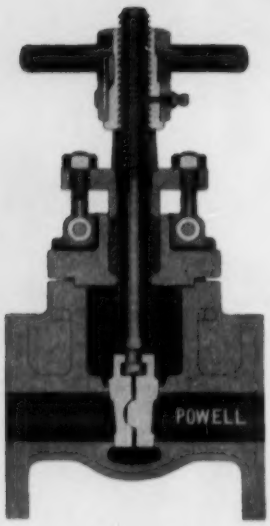
PETRECO®

DT10

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

Preferred for Precision and Performance



Powell Valves are the choice of engineers because they know every valve is precision made, meeting every specification—every time.

And there are other good reasons why engineers prefer Powell Valves—because Powell Valves are dependable . . . economical . . . and Powell has the COMPLETE quality line of valves.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have.

The Wm. Powell Company
Cincinnati 22, Ohio . . . 109th year

FIG. 2495 (Sectional)—Stainless Steel O. S. & Y. Gate Valve for 150 Pounds W. P. Double Wedge Disc is accurately guided to seat.

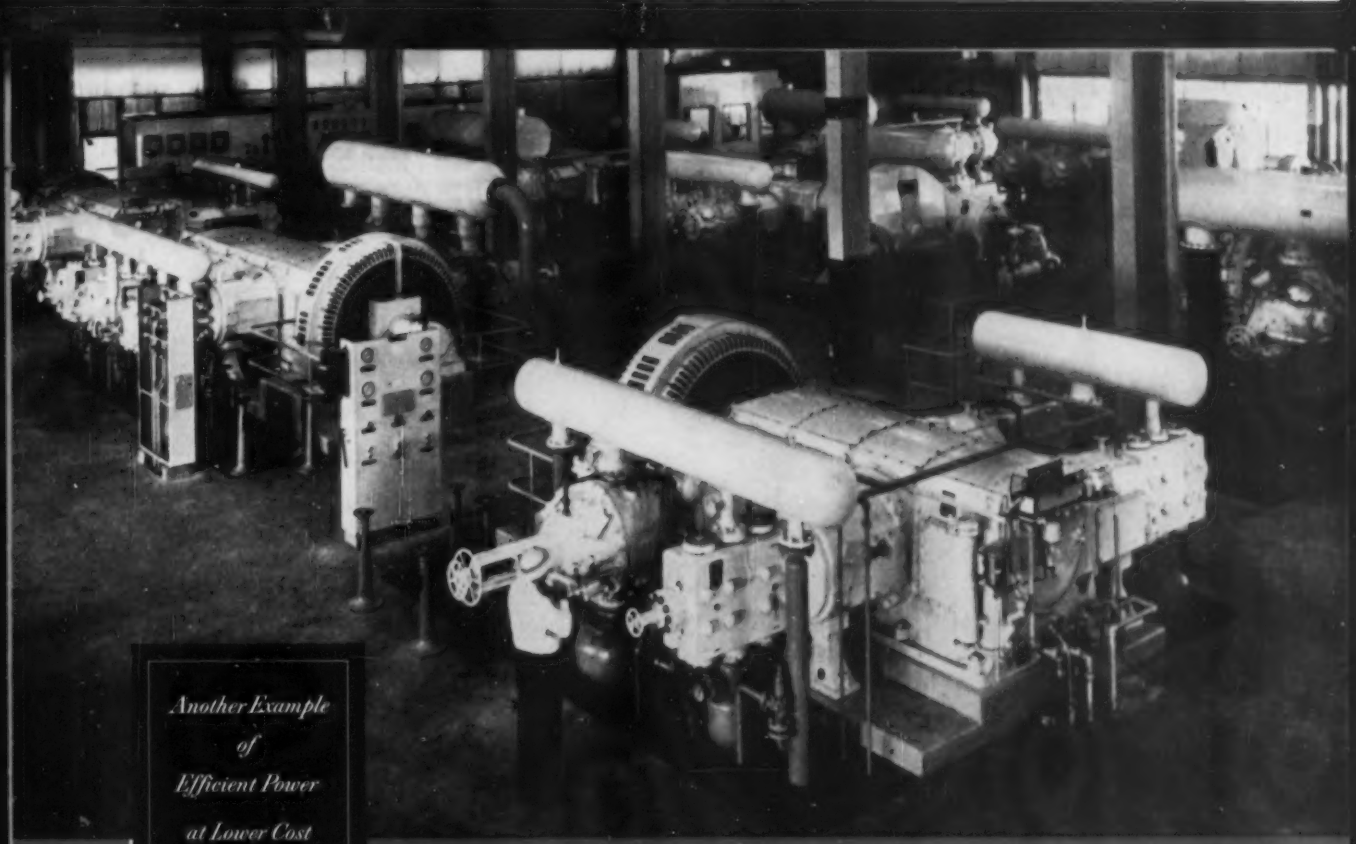
FIG. 375—Bronze Gate Valve for 200 Pounds W. S. P.

FIG. 2309—(Sectional)—Flush Bottom Tank Outlet Valve for 150 Pounds W. P. Disc Opens Into Tank.

FIG. 2193—Large Ni-Resist* Gate Valve for 200 Pounds W. O. G.

*Trade-mark of The International Nickel Co.

POWELL VALVES



Another Example of Efficient Power at Lower Cost

This over-all plant view shows several of the compact Cooper-Bessemer M-Line compressor units that deliver dependable performance in the Brea Chemicals, Inc. modern ammonia plant near Los Angeles.

HERE'S MULTIPLE-SERVICE FLEXIBILITY IN MODERN AMMONIA PRODUCTION

. . . with Cooper-Bessemer JM Compressors

● Twelve Cooper-Bessemer JM compressors, totaling 17,500 horsepower, are doing an efficient, economical job of handling a wide range of compressor services in the Brea Chemicals, Inc. 13-million-dollar ammonia plant near Los Angeles.

JM-4's for air, ammonia, mixed gas, hydrogen and recycle service, and JM-6's handling nitrogen compression, offer important savings to this producer of 235 tons of ammonia daily.

Here, to list but a few, are reasons why Brea, like so many other modern chemical producers, benefits from Cooper-Bessemer's century of compressing experience: there's extreme flexibility to handle a wide range of pressures and different gases, advanced design and metallurgy afford unusual strength and rigidity, there's five-step unloading at constant speed, the crankshaft is a steel forging of exceptionally large diameter thus low unit bearing pressures, compressor cylinder jackets are designed to insure adequate, uniform cooling, and the JM's exceptional compactness does not sacrifice accessibility or ruggedness.

If you're interested in compressing, write or call for full details . . . learn about *all* the plus features of these modern units. The nearest Cooper-Bessemer office will gladly cooperate.

MOUNT VERNON, OHIO

COOPER-BESSEMER

GROVE CITY, PENNA.

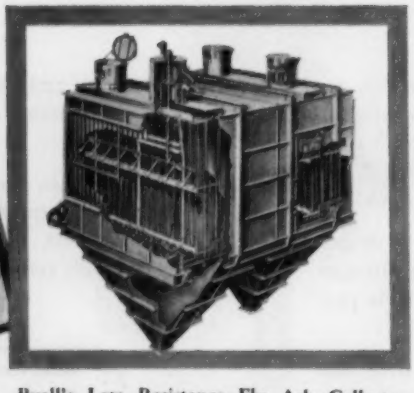
New York City • Seattle, Wash. • Bradford, Pa. • Chicago, Ill. Houston, Dallas, Greggton, Pampa and Odessa, Texas Washington, D. C. • Shreveport, La. • San Francisco, Los Angeles, Calif. • St. Louis, Mo. • Gloucester, Mass. • New Orleans, La. • Tulsa, Okla. • Cooper-Bessemer of Canada Ltd., Edmonton, Alberta—Halifax, Nova Scotia.

DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

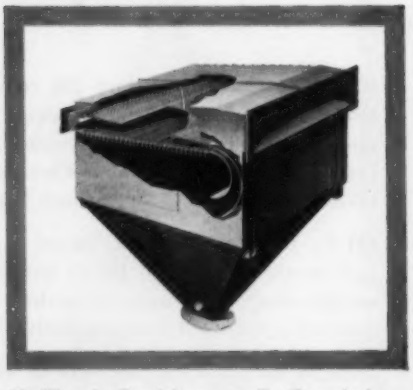
How Buell delivers the EXTRA PERCENT in Dust Collection Efficiency

In any cyclone dust collector there is an upward eddy preventing the separation and dropping-out of a percentage of particles. But in Buell Cyclones, the exclusive Buell shave-off design *harnesses* this up-flow—puts it to work! Result: extra efficiency without extra operating cost!

For the complete story behind Buell's *extra efficiency*, write Dept. 21-H, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.



Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or forced draft installations.



SF Electric Precipitator, a Buell exclusive, also delivers *extra efficiency* due to unique Spiralectrodes and continuous cycle rapping.

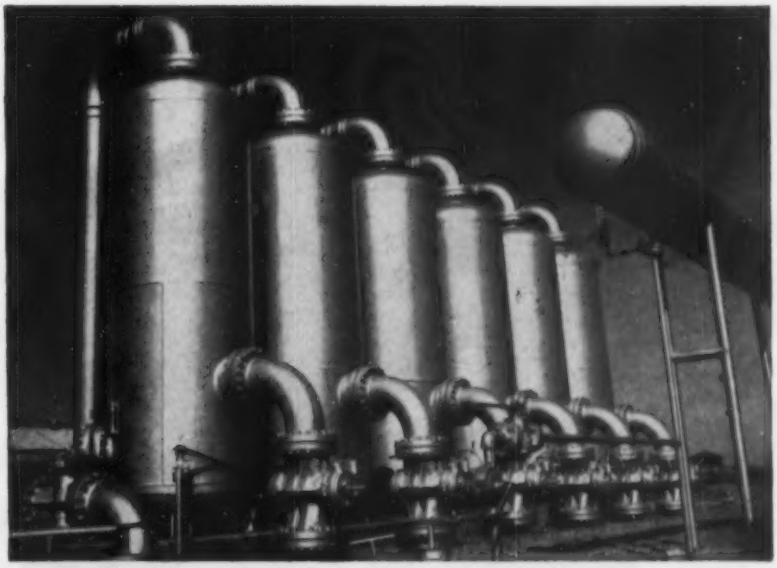
buell®

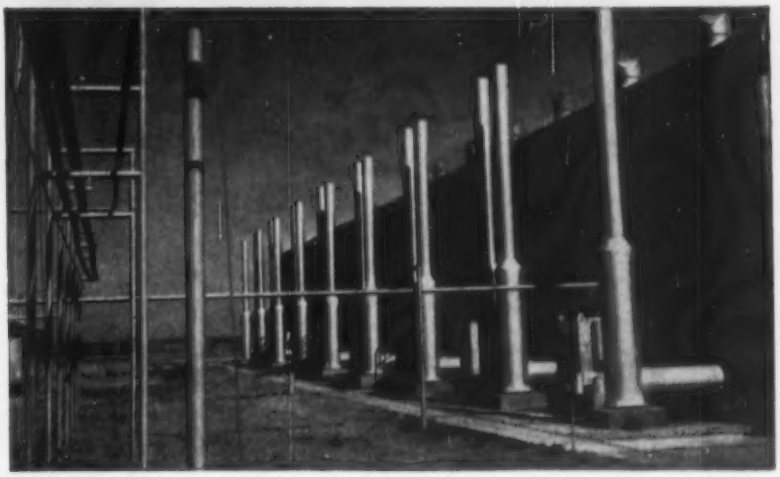
MECHANICAL ELECTRICAL

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

Compressor station gas cleaners are coated with Morris' Chrome Aluminum Paint to protect against all corrosive conditions. Northern finds that the aluminum coating lasts longer, reduces maintenance costs.

Northern Natural Gas Company *cuts maintenance costs* at this compressor station with Morris' High Heat Aluminum Paint





Exhaust mufflers at one of Northern's compressor stations. Operating under extremely hot conditions, these pipes are coated with High Heat Silicone Aluminum Paint manufactured by the Morris Paint & Varnish Company, East St. Louis, Illinois.

The Northern Natural Gas Company, Omaha, Nebraska, transmitting natural gas from Texas to Minnesota, is cutting compressor station maintenance costs with High Heat Silicone Aluminum Paint. This coating is used on "hot" exhaust mufflers on engines used to pump gas through the pipeline. Northern found that they had to repaint these surfaces several times a year until they tried high heat aluminum paint. Now the coating lasts from 1½ to 2 years, even under the hottest conditions. The company states that "the paint is doing an excellent job under the severe heat of Texas as well as in the cold temperatures found in Minnesota."

Other types of Morris' Aluminum Paint are used on various compressor station structures, with a resulting reduction in maintenance costs due to greater durability, high resistance to corrosion.

ALCOA does not make paint, but ALCOA Aluminum Pigments are used in more aluminum paints than any other brand. Special formulas, like High Heat Silicone, have been developed by your paint manufacturer to solve individual problems. Paints made to these formulas actually cost less, last longer, give utmost protection against heat, cold, sun, rain, smoke and fumes.

Write today for our two FREE booklets, *Painting With Aluminum*, and *Aluminum Asphalt Roof Coatings Make Time Stand Still.* They contain the latest, up-to-date information on aluminum paints and aluminum roof coatings. Use the coupon.

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Please send me your FREE booklets:
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Name_____
Company_____
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City_____
Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

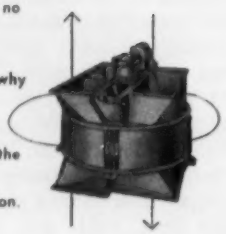
reduce slag

stay on stream at top capacity months longer with the Ljungstrom® Air Preheater

HOW FAST IS "WRITE OFF"?

By cutting turnaround time alone, the Ljungstrom means major savings for you. When you take the other Ljungstrom advantages into account—up to 20% fuel saving . . . more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . consistently higher through-put . . . higher product quality—you can see why a Ljungstrom is paid out in just a few months.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.



Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

Slag—primary cause of reduced capacity—can be substantially reduced by the Ljungstrom Air Preheater.

That's because preheated air mixes more thoroughly with fuel. The result is better combustion . . . and less slag-forming material present in the furnace. Oil tubes stay cleaner . . . stills stay on stream at top capacity for months longer. As an example, one pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom and modern high-temperature burners, the still operates continuously at 18,000/20,000 barrels.

The Air Preheater Corporation **60 East 42nd Street, New York 17, N. Y.**

Two important factors in catalyst performance are particle density and particle size distribution. Davison controls *both* independently. Thus we provide multiple grades of fluid cracking catalyst and so make it possible for you to select exactly the characteristics required for optimum performance under the special conditions found in your units.

Davison has for many years been the leader in the production of catalysts. The leadership was established and has been maintained because of Davison's ability to produce catalysts to best meet the requirements of individual fluid catalytic cracking units.

For information on Davison catalysts see your Davison Representative or write

Progress Through Chemistry

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

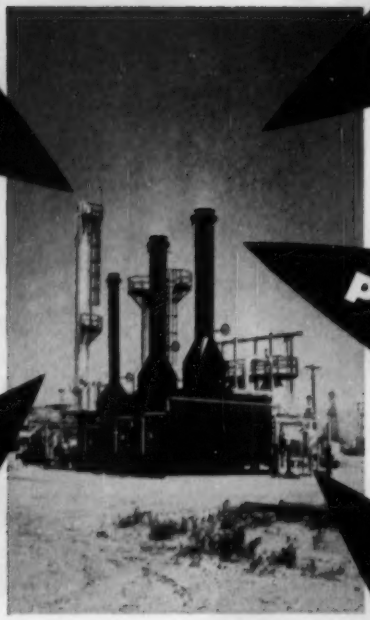
Baltimore 3, Maryland

Sales Offices: Chicago, Ill.; Houston, Tex.; New York, N. Y.; Baltimore, Md.
In Canada: Davison Chemical Company Ltd., Toronto

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels and Silicofluorides. Sole Producers of DAVCO® Granulated Fertilizers.

For more data on advertised products, use Readers' Service Cards, last page.

SOVAFORMING
CATFORMING
PLATFORMING
HOUDRIFORMING
ULTRAFORMING



WHATEVER
THE PROCESS—
THERE'S A **BORN**
HEATER DOING
THE JOB!

BORN HEATERS are especially designed for your heating requirements. Contact your nearest BORN Representative for complete information.

BORN Engineering Company
ENGINEERS and CONTRACTORS
TULSA, OKLAHOMA

BRANCH OFFICES: Denver, Colo.; Houston, Tex.; Los Angeles, Calif.; New York, N. Y.; Shreveport, La.
FOREIGN OFFICES: Paris, France: Premafrance
Canada: Canadian Brown Steel Tank Company Ltd., Brandon, Manitoba
Argentina: Brander & Cia. S. A., Buenos Aires

THREE NEW MODELS

DH-10
NEW DH-15
DH-20
NEW DH-25
DH-30
NEW DH-35
DH-40
DH-45

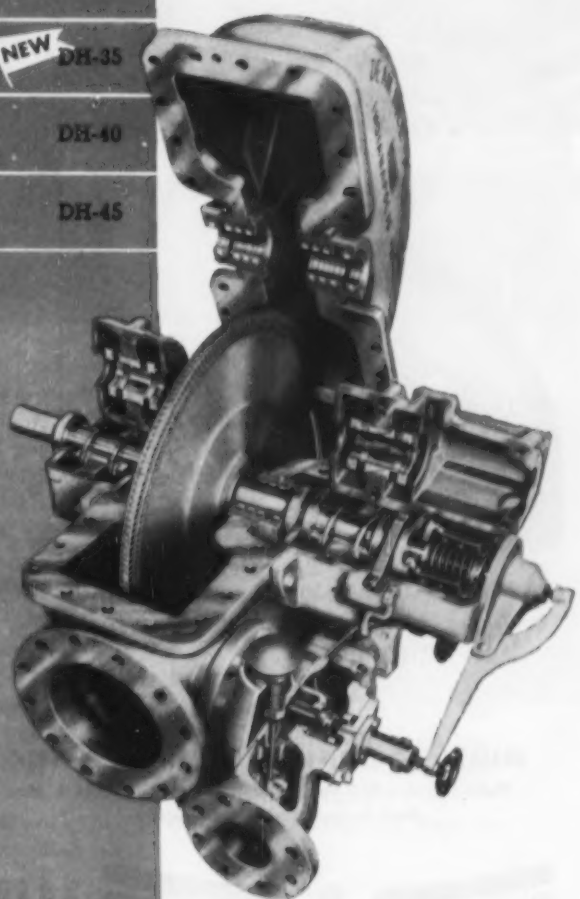
NOW YOU CAN CHOOSE FROM 8 MODELS TO MEET YOUR WORKING REQUIREMENTS

expand DH steam turbine line

The latest in a long series of advancements in the Dean Hill line of horizontal steam turbines is the addition of three new turbines introduced as intermediate models. These new models effect a more gradual increase in power ratings in the horizontal line. The reduced "spread" between ratings in the new 8-model line gives you a better opportunity to match the turbine to the job within a very close margin. Of course, this is always to your advantage in turbine selection.

Because the new models incorporate all the newest improvements made on the other sizes, the Dean Hill horizontal line is one of the most *advanced, complete* lines in the world. With single-stage construction and sleeve bearings, they are specifically designed to operate at medium steam pressures. Low power consumption results in outstanding operational economy of every model in the line.

Write for Catalog No. 500 for details on both vertical and horizontal DH turbines. Information includes cut-a-way illustrations, detailed line drawings, tables, horsepower curves.



DEAN DH HILL PUMP COMPANY

Pump and Turbine Engineers Since 1893
Indianapolis 7, Indiana

Sales Offices In:
Chicago, New York, San Francisco, Boston, Cincinnati, Denver, Albuquerque, El Paso, Salt Lake City, New Orleans, Philadelphia, Tulsa, Los Angeles, Pittsburgh, Houston, Dallas, St. Paul, Toledo, Cleveland, Grand Rapids, Birmingham, Ala., Memphis, Richmond, Mexico City, Montreal, Reading, Pa. The Hague, Washington, Charlotte, Casper, Wyo., Knoxville.

THESE MIDWEST "LONG TANGENT" ELBOWS SAVED $4121 IN PIPE

MIDWEST "LONG TANGENT" ELBOWS COST NO MORE THAN OTHER ELBOWS

Here are 1227 Midwest "Long Tangent" Elbows (12", 14" and 16" standard weight) ready for shipment to a chemical plant. Each Midwest "Long Tangent" Elbow has a straight section on each end equal in length to ¼ the nominal pipe size. Thus a 12" elbow saves 6" of 12" pipe while a 16" elbow saves 8" of 16" pipe. It doesn't take long to save a lot of pipe and a lot of money . . . in this instance $4121.

But saving pipe is not the only advantage of Midwest "Long Tangent" Elbows. They often eliminate short nipples and their extra welds . . . save time and money in lining up and clamping pipe and fittings . . . slip-on flanges are more easily applied. For all the facts, write for Catalog 54.

MIDWEST PIPING COMPANY, INC.
Main Office: 1450 South Second Street, St. Louis 4, Mo.
Plants: St. Louis, Passaic and Los Angeles

Sales Offices
New York 7—50 Church St. • Chicago 3—79 West Monroe St.
Boston 27—426 First St. • Los Angeles 33—520 Anderson St.
Houston 2—1213 Capitol Ave. • Tulsa 3—224 Wright Bldg.
Cleveland 14—616 St. Clair Ave. • Miami 34—2103 Le Jeune Rd.
STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

MIDWEST WELDING FITTINGS

MIDWEST WELDING FITTINGS Improve Piping Design and Reduce Costs

7055

The Mail Box . . .

"Timely, Informative"

To The Editor:

A trip to St. Louis, and the resultant high-stacked desk, have prevented me from answering your letter of September 19 before now. However, this tardy reply is in no way indicative of our appreciation of your thoughtfulness with regard to the sets of tear sheets you forwarded for our files.

We were certainly happy to cooperate on the preparation of the article ("Bender Process Sweetens at No Loss," September PETROLEUM REFINER) and have felt well rewarded by virtue of the excellent representation we received in a very fine issue of the REFINER. In my opinion your Process Issue is an excellent effort; it is informative, timely and very well set up.

PETROLITE CORPORATION
Fred F. Hubler
Advertising Manager
Los Angeles

"Management" Interest

To The Editor:

Answering your recent query, I would like to see you carry more articles on the development of career from the standpoint of company, job, outside interests, leadership, etc.

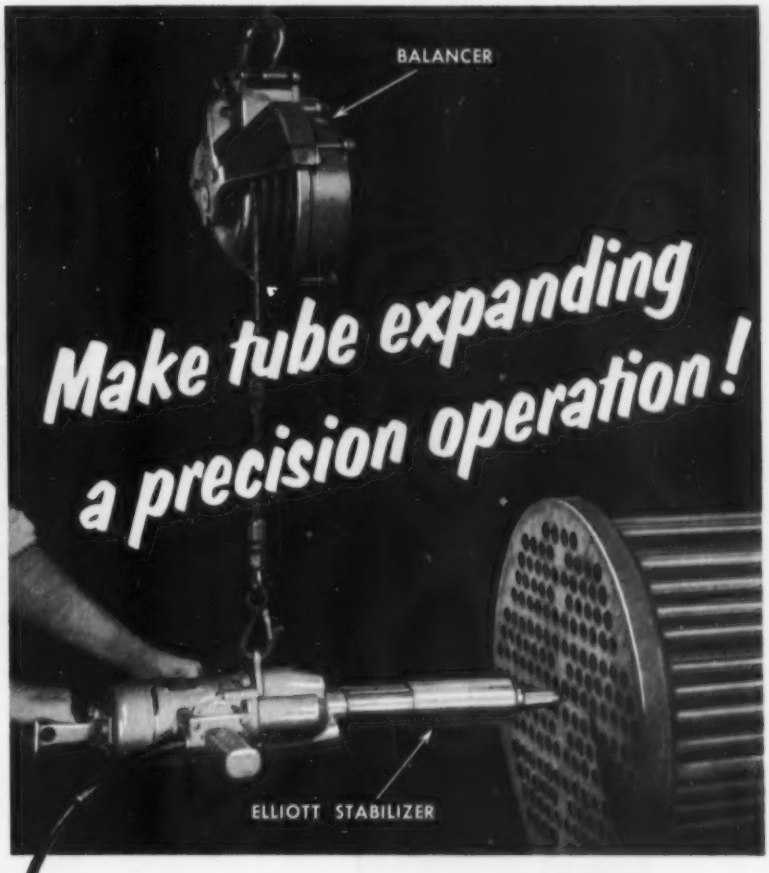
Robert T. Meldau
La Habra, Calif.

To The Editor:

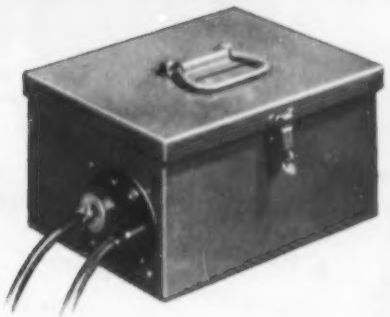
You have asked me what subjects deserve more space in PETROLEUM REFINER. I would say "keep up the few and add more on management and administration, personnel and industrial relations."

P. L. Nairn
Pasadena, Texas

Editor's Note—*Our section under the tag "As Management Sees It," which appears each month (see special classification on the index page) is being handled by a full-time man who, you can rest assured, will see to it that a high standard of articles continues to appear in this category. If any of our readers have specific topics to suggest or definite problems that deserve discussion, send them in and they will be given every consideration as subjects of possible future articles.*



THE ELLIOTT ELECTRICAL CONTROL



Get tight, uniform tube joints everytime and get them fast. The Elliott Electric Control, a torque-limiting device designed for use with any standard tapping motor, automatically balances outside voltage variables (without the need of a separate voltage regulator), controls the torque, and tells you when the tube has been rolled tight.

Speed the operation too with balancer and the Elliott Stabilizer which takes the wobble out of tube rolling. It centers and holds the expander case and cage, allowing operator to keep both hands on the motor. Full details in Bulletin Y-40. Address Elliott Company, Lagonda Division, Springfield, Ohio.

ELLIOTT Company

YS-G

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

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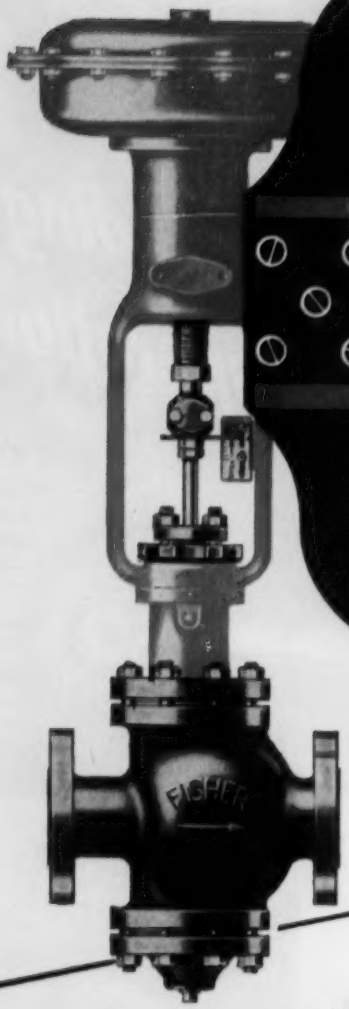
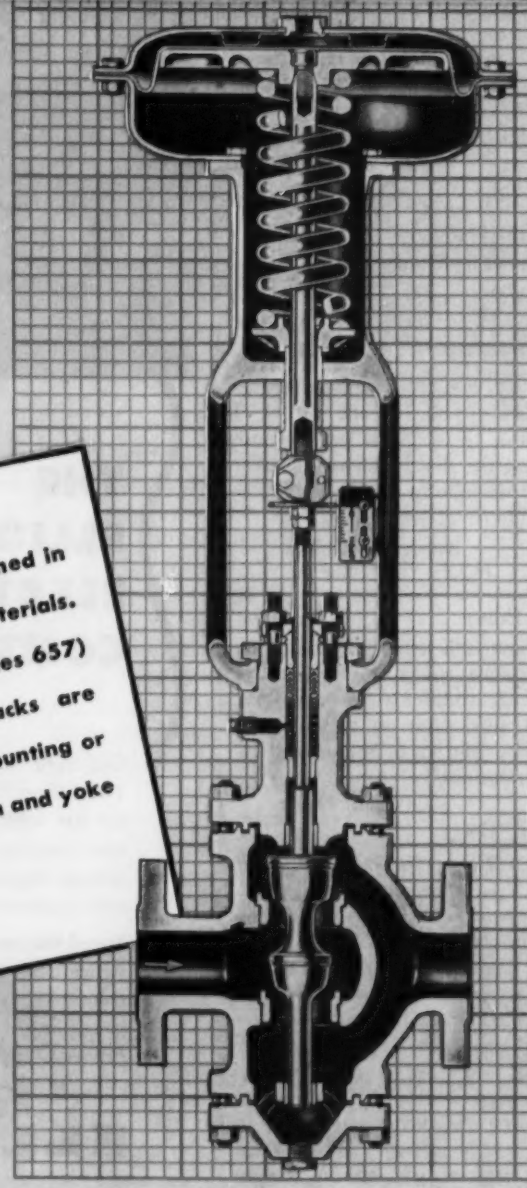
FISHER®

DIAPHRAGM





● Fisher Diaphragm Motor Valves are furnished in a wide variety of pressure ratings and materials. Topworks may be either direct acting (Series 657) or reverse acting (Series 667). Handjacks are available for either diaphragm casing mounting or yoke mounting. There are six diaphragm and yoke size combinations.

Improved

MOTOR VALVES

Improved PERFORMANCE FEATURES

- Bolted-clamp type stem connection allows stem adjustment of 50% of total travel. Can be disconnected in the field without stem damage. Will not shake loose from vibration or rotational inner valve forces.

- Rugged body to yoke connection with hammer lug nut. Topwork can be removed without disturbing stuffing box.

- Specially designed Buna N molded diaphragms with Nylon insert retain superior flexibility at low ambient operating temperatures. Provides linearity between operating pressure signal and travel, and gives maximum effective area.

- Bolted gland stuffing box with Teflon packing.

- Stainless steel clear view travel indicator.

- Spring ranges: 3 to 15 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER

Our 75th ANNIVERSARY

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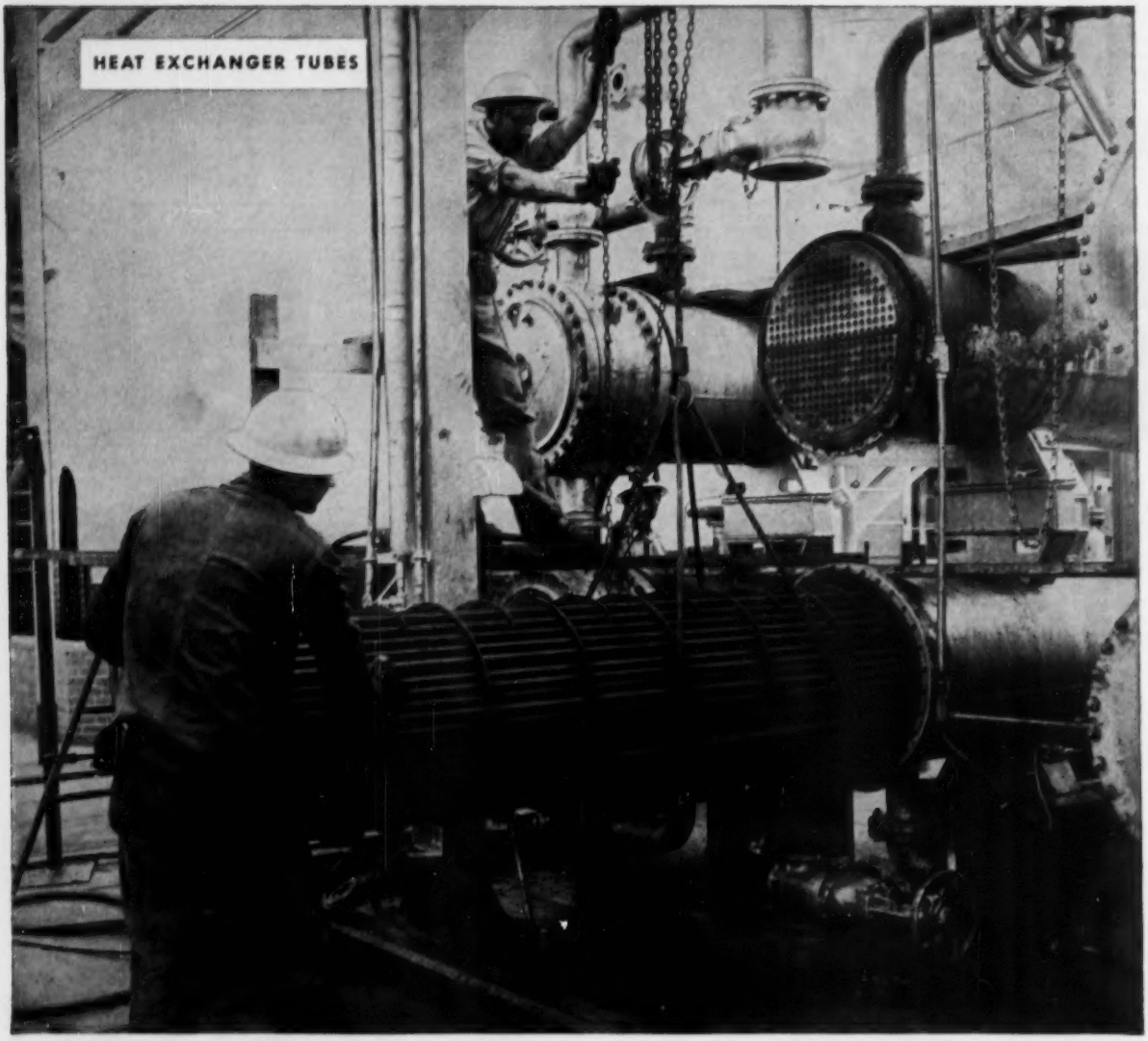

PERFORMANCE RECORD of these tubes under actual operating conditions is now a part of Anaconda's extensive collection of case histories.

Use of Anaconda Cupro Nickel, 10%-755 Tubes in Texas refinery may answer your tube problem

Imagine a collection of tube performance case histories that can answer many of the corrosion problems you face!

Our files bulge with such a collection. Here is experience accumulated over almost a century. Here are detailed records of tube performance under hundreds of actual operating conditions.

We can put the information in these files to work for you at once—to help you select the one best alloy for your job.

Here's a case history we are now adding—the use of ANACONDA Cupro Nickel, 10%-755* Tubes in the Port Neches Refinery of a major oil producer.

These tubes—in use two years—cool heavy gas oil in an Alco Exchanger on a Crude Pipe Still Unit. Gas oil at about 500°F.—mildly corrosive—comes in contact with the outside of these tubes. Brackish river water—with a high salt content—circulates through the tubes. Yet the tubes show no sign of corrosion.

CUPRO NICKEL, 10%-755 resists corrosion almost as well as Cupro Nickel, 30%-702; yet it costs much less. Polluted sea water and sea water with entrained air—even at relatively high velocity—have little effect on this alloy.

Help for your tube problem. No one tube alloy serves best under all conditions. Your problem is one of choosing the right alloy for the job. Let Anaconda's Technical Department help you. Write, outlining your operating conditions, to Dept. TD, *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*U. S. Patent No. 2,074,604 54109

ANACONDA®
Tubes and Plates
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A Quick Look at the Industry THIS MONTH

Petroleum REFINER
November, 1955

The national economy is well on its way to another record-shattering year. Now the Administration is worried about inflation. Total output of goods averaged $385 billion, at an annual rate, in the second quarter. And it's still climbing. It is already 7 percent above second quarter, '54, which was low point of recession last year. From here on additional increases in gross national product will be because of inventory building, less from retail sales.

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Sky-rocketing demand for petroleum products will continue to soar in '56. There will be 4.3 percent increase in over-all demand for products compared with 8 percent increase this year. Smaller '56 increase will represent a near-return to long term growth trend after '54 dip.

Some trend indicators: Next year, U. S. Department of Defense—largest single buyer of petroleum products—plans to purchase 10 percent more than in '55 ($926 million for 214 million barrels of petroleum products).

• **Prediction: Large increases in jet fuel needs and minor decreases in avgas needs.** Estimated avgas needs for '56 are 127,000 bpd, declining to 100,000 bpd in 1960 and 95,000 bpd in '65. Jet fuel will increase from 245,000 bpd in '56 to 324,000 bpd in '60 and 340,000 bpd in '65.

• **During second quarter of '55** U. S. car owners (nearly 50 million) spent 8 percent more for gas and oil than for same period last year. *Three cents of every dollar we spend goes for gas and oil.*

• **Chemical industry sales curves are increasing** 7 percent yearly for inorganics, 10 percent for organics and 11 percent for plastics.

• **Earnings of seven major petrochemical companies** showed a 25 percent average increase over first half of '54.

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Costs on items purchased for use in the petroleum industry continue to increase. Basic steel prices are up about 5.8 percent. Seven percent increase in tubular goods will up industry costs approximately $250,000 for remainder of '55. Increases are also expected in electric motors, conduit, manila rope, steel furniture, paper and printing.

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Phillips Petroleum is applying solvent fractionation to catalytic cracking feed preparation. Result: Less carbon during cracking, more total gasoline and more olefins suitable for alkylation or polymerization.

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Unorganized segments of oil and chemical industries are immediate targets for first organizing campaigns after AFL-CIO merger in December. Pin-pointed areas also include non-union South and white collar workers in industry.

Guaranteed annual wage is meeting resistance at the collective bargaining table. Example: In the electrical manufacturing industry, the CIO failed to get a foot in the door, despite months of plugging its demand for company payments to supplement jobless benefits. The union settled for higher wages and a five-year contract. A similar outcome is not unlikely when GAW is presented to the oil industry.

Oil workers still receive the "fattest" pay checks in the nation. Average—$99.95 weekly. Weekly average in factories is $20 less or $77.90. Two other examples: $95.40 for workers in primary metals and $94.02 for those in transportation equipment. All are up over a year ago.

A Quick Look at the Industry (continued)

Industry's college scholarship contributions will top all records in '56. Ford Foundation ($20 million) and the Carnegie Corporation ($0.5 million) are giving $21.5 million to newly organized National Merit Scholarship Corporation. Students will be selected on nation-wide competition basis. Only the "needy" will receive full four-year financial help. Others will get $100.

Major oil industry contributors are Jersey Standard and Shell. Jersey affiliates will make a "first advance" of $1.5 million ($0.5 million over last year) to Esso Education Foundation. Money will be used to aid privately supported colleges and universities.

Shell will underwrite summer seminars at Stanford and Cornell Universities for 60 science teachers yearly. Purpose: To help offset dangerous cutback in science teaching on secondary level—a basic cause for critical shortage of graduate scientists.

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Word of warning to tax payers—keep a wary eye on your own high schools. Many are cutting out laboratories for chemistry, physics and other sciences. Some schools are eliminating the entire courses. In keeping with this dangerous trend, U. S. colleges turned out 57 percent fewer high school science teachers and 51 percent fewer mathematics teachers last year than in '50. Providing facilities and teachers may be expensive—but it will be much more expensive in the long run to have high school graduates who lack this basic training.

—•—

Engineers' starting salaries are taking upward swing. Last June, engineer grads at the Illinois Institute of Technology averaged $381 per month. Starting pay in previous years. 1949, $282; 1950, $288; 1951, $295; 1952, $328; 1953, $362, 1954, $368.

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Los Angeles smog fighters may soon ease tight pressures and sharp accusations aimed at refiners. Latest ruling bans open oil refinery ponds, separators, sumps and sewers. However, county officials admit voluntary control programs have reduced vapor losses from these sources from 95 tons daily in '51 to 15 tons daily in '55.

One prominent oil man says next step in anti-smog battle is up to the public. He claims oil industry is minor factor in situation today, leaving automobile exhausts and rubbish burning as remaining big, uncontrolled smog sources.

—•—

Prediction: Rubber industry will chalk up best business year in '55. Consumption, if it reaches predicted 1,440,000 long tons, will top previous high in 1953 by 7 percent. It's certain that synthetic rubber will set a record, will account for 985,000 long tons of total consumption.

—•—

Fluid coke will be used first time commercially as fuel to generate electricity at Newark, New Jersey's Public Service Electric and Gas Company. Contract for total output—about 170 tons daily—is from world's second fluid coking unit recently completed at Esso Standard refinery in Baltimore. First fluid coking unit was dedicated last March at The Carter Oil Company's Billings, Mont., refinery.

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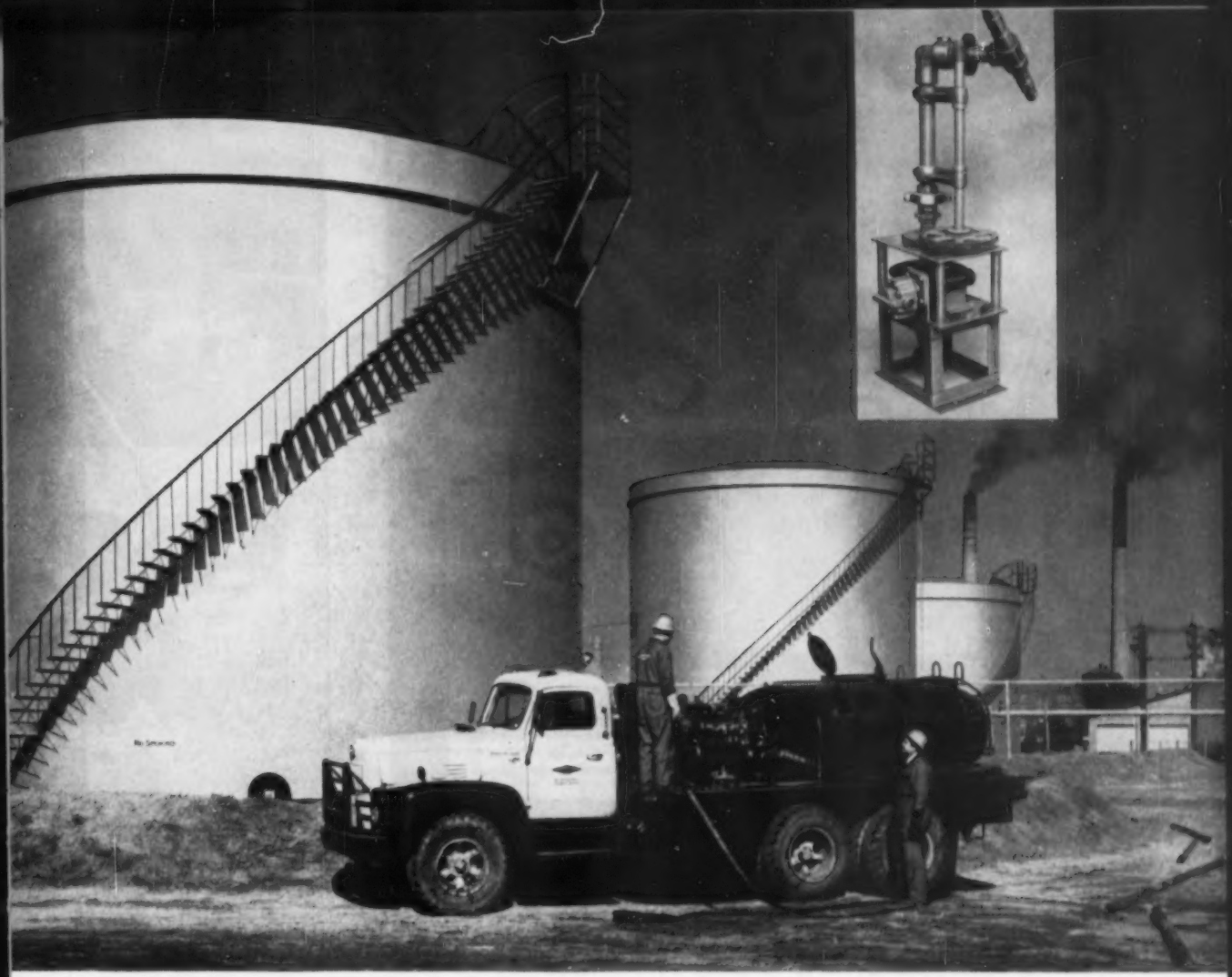
Ninety-five new oil fields were discovered in the U. S. during September. The most promising: An Amerada find in Woods County, Oklahoma, flowing 285 barrels of 49-gravity oil daily; Cities Service's Lea County, New Mexico, well making 894 barrels of 39-gravity; Phillips' new 543-barrel 59-gravity oiler in Reagan County, West Texas; Humble's Acadia Parish, Louisiana, deep discovery good for 232 barrels of 43-gravity a day; and a Graham County, Kansas, opener potentialed at 1142 barrels daily by Sunray-Mid-Continent.



3 DAYS THAT SAVED $10,000

DOWELL solvent sprayer cleaned tank at fraction of ordinary time and cost

Rust has no place in motor oil. Yet rust deposits were contaminating the motor oil additive stored in this tank. The refinery operator decided that they had to be removed.

His problem: The refinery's storage facilities were limited. Thus outage time for cleaning the interior of the 60 by 45 foot tank was crucial. And he estimated sand blasting would take six weeks, cost $12,000.

His solution: He consulted his local Dowell chemical cleaning engineers. They cleaned the tank with a special Dowell-designed tank spraying tool. The tool was used to spray thickened solvent, which clung to interior walls and ceiling. Also, the tool was used to flush the tank, spray regular solvent and, finally, to apply an anti-rust solution. No personnel had to enter the tank during cleaning.

His results: The contaminating rust was removed. Cleaning time totalled three days, including tank preparation and buttoning up afterwards. The operator saved about $10,000 in cleaning cost alone, not counting the saving in outage time.

Dowell tank cleaning is fast, avoids scaffolding, uses solvents and techniques tailored to solve your particular problem. Mobile Dowell units bring all cleaning materials and equipment to you. Call Dowell's chemical cleaning experts. For fast service, their offices and stations are located in major industrial areas. Or for more information, write Dowell Incorporated, Tulsa 1, Oklahoma, Department K-31.

chemical cleaning service for industry

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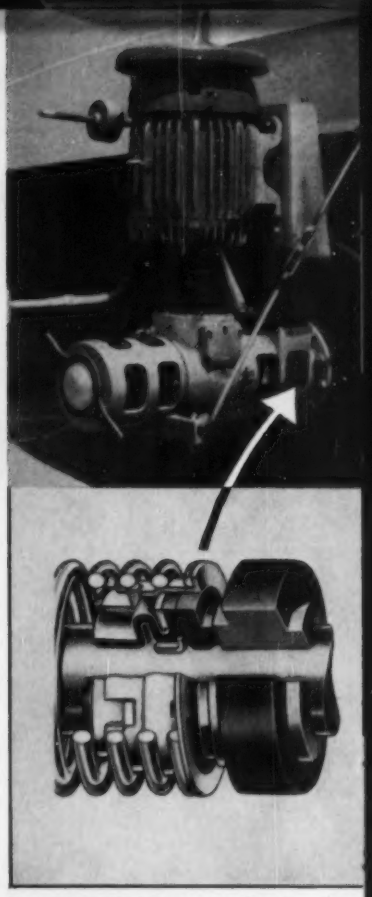

YOU CAN REPLACE A LIGHTNIN rotary seal in a few minutes—without special skill, without draining the tank or dismantling the mixer, without losing a pint of product. Seal is shown here without housing, to illustrate components.

Newest cost-saver in side entering mixers:

End stuffing box repacking . . . forever

with a rotary seal that's easy to replace

Now you can enjoy the solid maintenance savings of leakproof rotary sealing in a side entering mixer—without the headaches seal replacement *used* to cause.

For here, at last, is a rotary seal that runs *years* without adjustment—yet can be replaced *in a few minutes* when necessary, without draining the tank or dismantling the mixer, and *without need for special skills.*

Here's what you gain when you specify LIGHTNIN Mixers with new LIGHTNIN Seals:

1. You end leakage—for good. The seal positively will not leak during its operating life.
2. You *eliminate* the cost of repacking stuffing boxes. The LIGHTNIN Seal takes the place of a stuffing box. Under most conditions, it runs smoothly for *years* without changing.
3. You stop costly "nursing" of stuffing boxes. The seal *never* needs adjustment.
4. And most important (because it's never been possible before)—you can replace a LIGHTNIN Seal *in a few minutes,* should it ever become necessary. Only one simple *cartridge* component to remove and replace—and you're back in operation. So simple, anyone who can handle a wrench can do the replacement job *in minutes.*

Already, many oil companies are using LIGHTNIN Seals. Users report savings running into many thousands of dollars per year. Your LIGHTNIN Mixer representative can give you the full story—show you how much *you* can save. Call him today. Or get the facts by mail: Send the coupon for 8-page, fully illustrated bulletin.

Get the cost-cutting facts now... New 8-page Bulletin B-111 shows how you get maintenance-free sealing that really slashes fluid mixing cost to a new low. Send also for LIGHTNIN Mixer catalogs listed here. Free—no obligation. Just check data you want, tear out and mail to us today with your name and company address.

- ☐ B-111 LIGHTNIN Rotary Mechanical Seals
- ☐ DH-50 and DH-51 Laboratory Mixers
- ☐ B-102 Top Entering Mixers (turbine and paddle types)
- ☐ B-103 Top Entering Mixers (propeller types)
- ☐ B-104 Side Entering Mixers
- ☐ B-107 Mixing Data Sheet
- ☐ B-108 Portable Mixers (electric and air-driven)
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MIXING EQUIPMENT Co., Inc., 196-m Mt. Read Blvd., Rochester 11, N. Y.

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MIXCO fluid mixing specialists

GAW, SUC, GAP or Steady Job?

NO ONE CAN say yet just what the effect of the guaranteed annual wage is going to be on American industry but the refining industry itself can look the issue straight-in-the-eye. Some of the publicity on these plans to build up large funds for supplementary payments during periods of layoff give the impression that this great advance in industrial relations is comparable to the eight-hour day or Henry Ford's famous $5-a-day wage. Whatever advance it will make depends not on the plan but on the strength of the company paying them. Such plans, like the eight-hour day or the $5-a-day wage, were made possible only by the increasing productivity of American industry. The real goal is increased productivity and continuous employment. Unions have now come to recognize this and in fact the UAW, chief promoter of the plan, has said that "we are not asking for pay for idleness—we are asking for steady jobs."

Label Is Changed—Management in answer to GAW has asked rightfully if they can expect GAP or "Guaranteed Annual Profit." The question has apparently cut to the quick as some unions have now relabeled their demands as SUC or "Supplementary Unemployment Compensation." Whatever the plans are called, the refining industry can point with pride to its own strength and productivity which has resulted in steady jobs for its employes. A. W. Scott, president of the National Petroleum Association, has looked the issue straight-in-the-eye and we are happy to quote from his recent address before the NPA:

"The petroleum refining industry can well be proud of its record of providing steady jobs. The figures of the Bureau of Labor statistics on labor turnover show that less than one worker out of every 100 in the refining industry leaves his job each month. This rate includes separations for all causes—those discharged, laid off, retired, or who resigned, are disabled, or die. This rate of labor turnover for petroleum refining is the lowest of any industry in the United States. There are a number of reasons for this. The most important of course are economic. I am indebted to a recent article by William Zimmerman, industrial relations director for the Sun Oil Company for a summary of five of the most significant reasons:

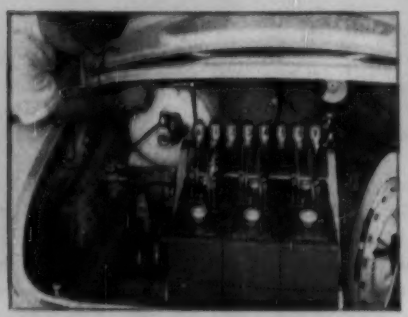
- "The demand for oil products has grown; speeded by the improvements in the quality of petroleum products, by the development of new products to meet new needs, and by the fact that improvements in efficiency have reduced costs that are reflected in product prices.
- "Many oil products have become necessities and are purchased on a year-round basis during good times and bad.
- "Although not true in early years, the oil industry today achieves uniformity of operation throughout the year by building up gasoline stocks in winter and spring and fuel oil stocks in summer and fall. This is only one of a number of steps which have been taken by the industry to stabilize employment and to make operations profitable throughout the year.
- "The oil industry utilizes a relatively large amount of capital investment for each worker employed.
- "The oil industry, in a sense, is like a huge industrial belt-line. Most of its operations are on a 24-hour basis. Thus, unlike some industries, there is no "stop-and-go" about the oil business. This is to a large extent due to the fact that many operations in the oil industry like pumping a well, operating a pipe line or running a refinery are operations which by their very nature cannot be turned on and off easily.

What Makes Stability—"But in addition to that, we must recognize the fact that the growth of integration in the industry which has made it possible for petroleum to move from the well through the manufacturing processes and to the consumer under the control of one company have contributed greatly to the stability of the industry's operations, and this in turn has been greatly to the benefit of the public in providing steady employment as well as providing a constant supply of products at reasonable prices.

"These economic factors add up to the obvious fact that, more important than any artificial wage plans, the best thing a company can do for the public or for its employes is to operate efficiently. Under our competitive system the only way it can stay in business and pay regular wages, is by supplying the needs of the public at reasonable prices.

"While I am giving the major credit for this achievement to economic factors I do not think we should overlook the fact that there are also some human factors involved in this question. The oil companies which have managed to stay in business have made a real effort to provide regular employment for their workers even when it was not always economic to

The arrow is pointing to the Du Pont test car's fuel-injection pump, which is driven by the same shaft as the distributor.



From these tanks in the trunk, any of six different fuels can be selected for testing in the fuel-injection engine.

Fuel-injection car being tested on Du Pont Petroleum Laboratory's chassis dynamometer.

Special Du Pont test car studies advantages of *fuel-injection*

Will fuel-injection soon replace our standard carburetor system? As yet, no one knows the answer! But there are certainly many advantages to recommend it . . . such as freedom from carburetor icing, reduction of vapor lock troubles and improved power. And it will permit automobile styling changes since the hood lines can be lowered.

But how would a trend to fuel-injection engines affect the refiner? As a large supplier of the chemical additives used to improve fuel performance, we at Du Pont are interested in this development. And to study it thoroughly, the Du Pont Petroleum Laboratory is using a specially equipped test car.

The car has a Lincoln V-8 engine to which has been added an American Bosch fuel-injection system and special instrumentation. In addition to road work, the Petroleum Laboratory has tested the car on the Laboratory's chassis dynamometer.

From testing it with a variety of gasoline blends, the Laboratory has found that *fuel-injection permits greater flexibility in blending fuels. Fuel components with higher vapor pressures can be used, and it is possible that increases in the use of higher end point fuels may be practical. These wider tolerances could result in significant economic advantages to refiners,* as well as welcome benefits to the motoring public.

The Du Pont Petroleum Chemicals Division now has this car on a demonstration tour throughout the United States.

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do so. In the Pennsylvania field we have had occasion just recently to witness the efforts that were made by Socony Mobil Oil Company to take care of the workers who were displaced when the company shut down its refinery at Olean, N. Y. Perhaps all of you have read about the efforts which Socony made to transfer these workers, at company expense, to the new refinery built by one of its subsidiary companies at Ferndale, Wash., and to find jobs elsewhere for those who did not wish to make the move. Probably you are familiar with similar efforts that have been made by other companies."

Keeping Up With Demand?

SOCONY MOBIL'S President Albert L. Nickerson makes the following prediction: One year from now, total domestic demand for petroleum products will be 8,650,000 barrels a day—a four percent increase over 1955.

By 1960, domestic demand will reach 9,700,000 barrels daily and 1965 will be 10 percent above that—more than 10,650,000 barrels a day.

This is what Nickerson's prediction means to the refiner: In 10 years, the domestic demand for petroleum products will increase 2,350,000 barrels a day over the present 8,300,000 barrel daily consumption rate. Simple mathematics reveal that this increase in demand will require U. S. refineries to expand capacity an average of 235,000 barrels a day each year for the next decade.

This should certainly offer little challenge to the refining industry. From 1946 to 1955, refinery capacities have increased at an average annual rate of 350,000 barrels per day (last month, oil companies had an excess of 13 percent in domestic refining capacity). The same rate of increase holds true for the future. Refiners are now expanding their facilities to reach a current goal of 9,000,000 barrels a day capacity by January 1, 1957. This goal becomes quite realistic when you consider that oil companies will receive special tax benefits on all expansion programs completed by that date.

When we think of total refinery building, we must realize that the industry will have to replace obsolete equipment as well as add new capacity. Estimated expenditures for refineries alone in 1955 will probably reach $1 billion. This is merely another indication of the far-sightedness of the refining industry. Refiners know definitely that there will be continued growth, and they are spending money now to provide the facilities of the future. It has been estimated that within a ten year period (1950-60), the refining industry will have invested approx. $8 billion in new facilities.

The industry knows definitely that there will be continued growth, and is spending money now to provide the facilities of the future. There is no question that the industry will maintain adequate refining capacity to meet market needs now—ten years hence—or at any time in the future.

Engineers—What About Tomorrow?

CURRENT rumblings about the shortage of engineers and scientists may well extend far into the future.

The National Science Foundation recently surveyed 200 employers of research scientists and engineers. This is what they learned: (1) Half the firms made no point of numerical shortages, but stated that the expansion of research and development programs is being hindered by their inability to find people with the kind and quality of training needed. (2) One sixth of the companies reported moderate shortages in general engineering and scientific research staffs. (3) One third are facing acute shortages of major proportions.

The fact that only half of the 200 firms have met their numerical requirements is sufficiently ominous. And few of those are satisfied with their ability to meet the demands of current or future research and development programs. This is today's problem—and it remains unsolved.

What about tomorrow? Other surveys have revealed that many high schools are cutting out laboratories for chemistry, physics and other sciences. Some schools are eliminating the entire courses. In keeping with this dangerous trend, U. S. colleges turned out 57 percent fewer high school science teachers and 51 percent fewer math teachers last year than in 1950.

A solution to this critical problem might well be found in these words by Dr. Willard F. Libby, Commissioner of the Atomic Energy Commission: "Without in any way depreciating the important need to strengthen the teaching of science in secondary schools . . . I would add that that is not enough. We must also provide tools for research in the fields of science which seem ready to yield the most rapid advances. The opportunity to explore these fields is the attracting force which draws the student into a scientific career and provides the stimulus to make his studies productive."

Distillate Stocks Need Cutting

THE GREATEST accumulation of distillate fuel oil ever made is now in refiners' tanks, and a cold winter is needed to drop these supplies to better levels by next spring.

Unless consumption is stepped-up sharply by cold weather, present high inventories indicate that excessive fuel oil stocks will present the industry with a problem in 1956. A mild winter would do just that.

Caution must be exercised in the next five to six months in order not to make too much distillate fuel. At the same time the normal winter problem of building gasoline supplies to excess must be avoided.

Surplus distillate stocks were created by the high level of refinery thruput during the last four months. U. S. inventories rose 7¾ million barrels during the four weeks ended October 14, when they totaled nearly 149 million barrels. That was 15½ million barrels higher than year-ago stocks had been.

It was encouraging to see a reduction in refinery runs during the past several weeks. As a result, a sizable cut-back in distillate production occurred.

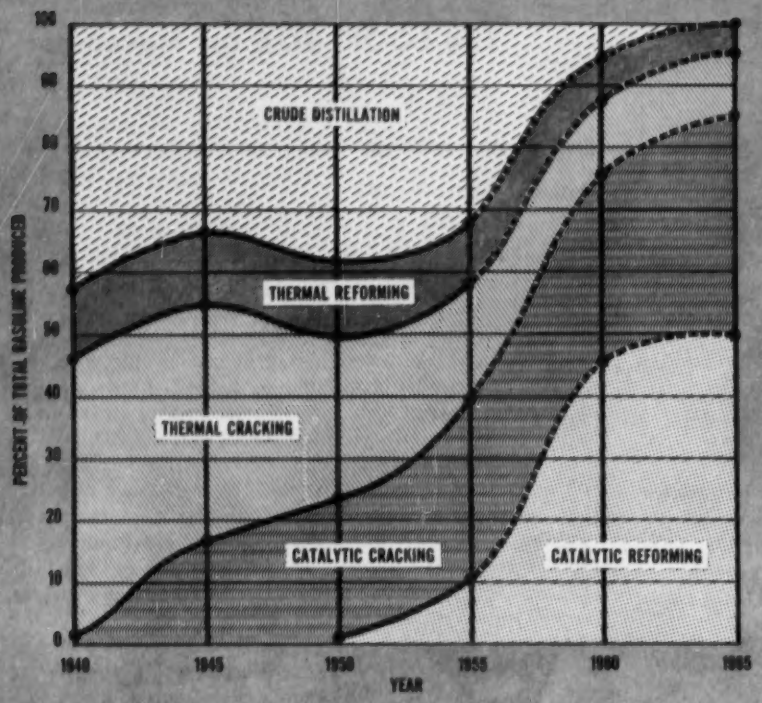

FIG. 1. Trends in processes for making gasoline. By 1965 catalytic reforming may account for 50% of all gasoline.

How to get your top octanes more economically

By HAROLD J. GIBSON
Ethyl Corporation, Detroit, Michigan

WITH the growing trend to better-grade gasolines, the cost of producing those last few octane numbers has steadily increased. As a result, refiners are looking anxiously for more economical ways to get their top octanes.

Already octane numbers in the 97 to 98 range are being marketed in the East and Southwest. And the trends for all U.S. refineries in terms of pool, regular and premium fuels show that octane numbers are continuing a slow, steady rise each year.

To meet the demand for higher-octane fuels, refiners are being constantly forced to change their processes. A look at the graph at the top of the page (Fig.1) will show you the gradual changes in process evolution. Note that by 1965 catalytic reforming may account for 50% of the total gasoline production in the industry.

Depending on the specific octane-improvement problem, the economic answer usually consists of a combination of tetraethyllead and various processing steps. (Some of these processing alternatives are displayed in Fig. 2.) The question becomes: How to determine the most economical way to get those top octanes. Only by conducting a detailed economic analysis can a refiner be sure of finding the best solution for his refinery, for from an economic analysis he can determine the proper balance between lead and a processing alternative.

An economic analysis will take into consideration all of the factors that affect the costs of making your gasoline: for example, optimum rates and yields, raw-material costs, product prices, operating manpower, maintenance and repair, utilities, depreciation, investment charges and reasonable "pay out."

TABLE 1. Estimated Pool Octanes and Premium—Regular Octane Numbers

		With 2.2 ml/gal TETRAETHYLLEAD	With 3.0 ml/gal TETRAETHYLLEAD
At the end of 1953	Pool	88.0	89.4
	Premium	92.9	94.3
	Regular	85.9	87.3
At the end of 1954	Pool	89.3	90.7
	Premium	94.2	95.6
	Regular	87.2	88.6
At the end of 1955	Pool	90.8	92.1
	Premium	95.7	97.0
	Regular	88.7	90.0

Octane improvement analyzed

From such an analysis you can determine the economics of octane improvement, which is the tool for obtaining the optimum sequence of processing steps and attendant use of tetraethyllead. Analyzing octane improvement costs calls for a thorough understanding of unit operating costs, particularly when incremental expenses are being considered.

There are several approaches for analyzing the costs of octane improvement at higher levels. At Ethyl we have found, through our studies of the economics of top octanes, that the key to cost analysis is a value called *incremental cost*. Simply expressed, this is the rate at which costs increase as you raise the octane number. It can be expressed conven-

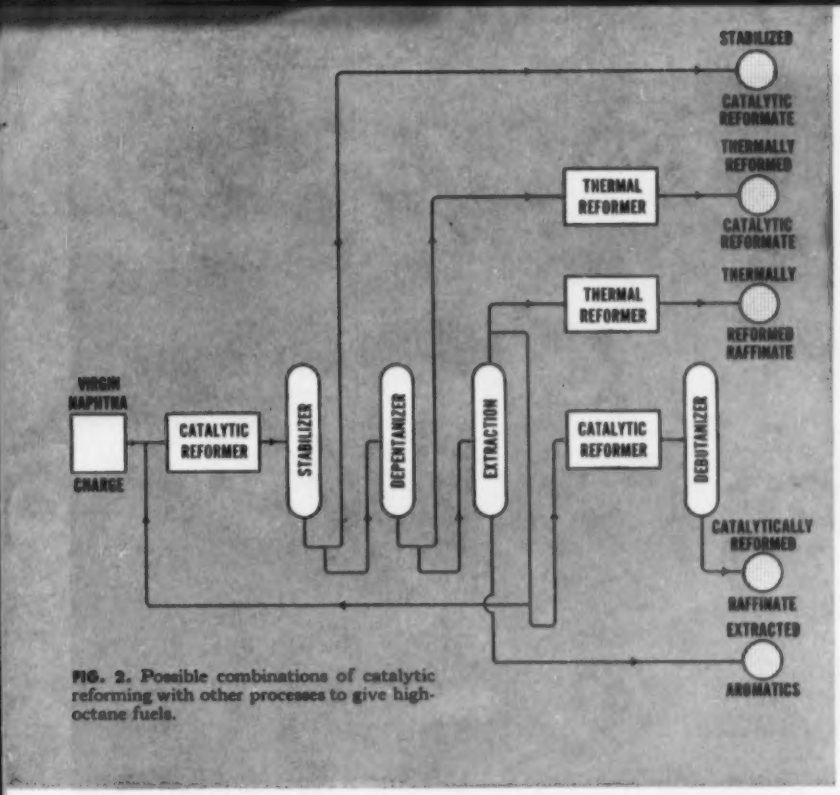

FIG. 2. Possible combinations of catalytic reforming with other processes to give high-octane fuels.

iently in cents per Research octane number per barrel. (¢/RONB).

Once you determine incremental costs, the next step is to make sure you are employing the best possible process at each point. By plotting the cost curves on a chart, you will see that up to a point the cheapest way to improve gasoline is with lead. Then lead becomes closely competitive with mild reforming methods.

After you reach an incremental cost of about 5¢/RONB, it again is definitely cheaper to add tetraethyllead. And finally when the full 3 cc of lead is used, you must return to reforming—this time at greater severity.

Today there's a greater trend toward using lead in higher concentrations for, as one industry spokesman put it, "tetraethyllead has decreased steadily in price while the costs of refinery construction have continued to rise rather sharply."

With constantly increasing gasoline-quality demands facing the refiner, it has become increasingly important to define the optimum route to high-octane fuels. Lead addition now costs an average of 4 to 5 cents per Research octane number per barrel, and this is directly competitive with the cost of mild reforming operations for octane improvement. As product octane levels increase, refiners may have the choice of using maximum tetraethyllead—3 ml/gal—or going to more expensive reforming operations—more severe single pass reforming or extraction followed by raffinate reforming. Here—even though lead susceptibility decreases somewhat in aromatic reformates—the cost of octane improvement by lead becomes increasingly more attractive as compared with various processing alternatives. Where extremely high octane levels are required, a refiner has little choice but to use the more economic tetraethyllead to the maximum and then to vary his processing alternatives to give the desired product quality if he wants to hold his manufacturing costs to a minimum.

KNOW THIS EQUATION?

$$¢/RONB = \frac{(Y-100-F)(Pg-9.4T) + Pb(F+G) + Pf100H - 100E}{100\,RONp - 100\,RONn - 10F + Y(RONr - RONp)}$$

You should if you are making an economic analysis. Write for a copy of a recent 50-page report giving a definition of terms of this equation and other information on new processing alternatives and on the economics of top octanes. Address your request to Department No. 14, Ethyl Corporation, 100 Park Avenue, New York, New York. No charge.

HOW Ethyl Research can help you

Our Refinery Technology staff, backed up by the extensive facilities of the Ethyl Laboratories, will be glad to share their experience with your economics people when you conduct a cost analysis of your top octanes.

We will work with you, or if you prefer, we are even equipped to do a complete cost analysis for you.

We can help you answer these and other questions: When should you use "Ethyl" antiknock compound in preference to increasing the catalytic reformer charge rate? How does increased severity of reforming affect your costs? When should you carry your tetraethyllead content to the maximum allowable—and under what circumstances?

Your Ethyl Representative will be happy to arrange an appointment for you with one of our Refinery technologists.

ETHYL CORPORATION
Research Laboratories

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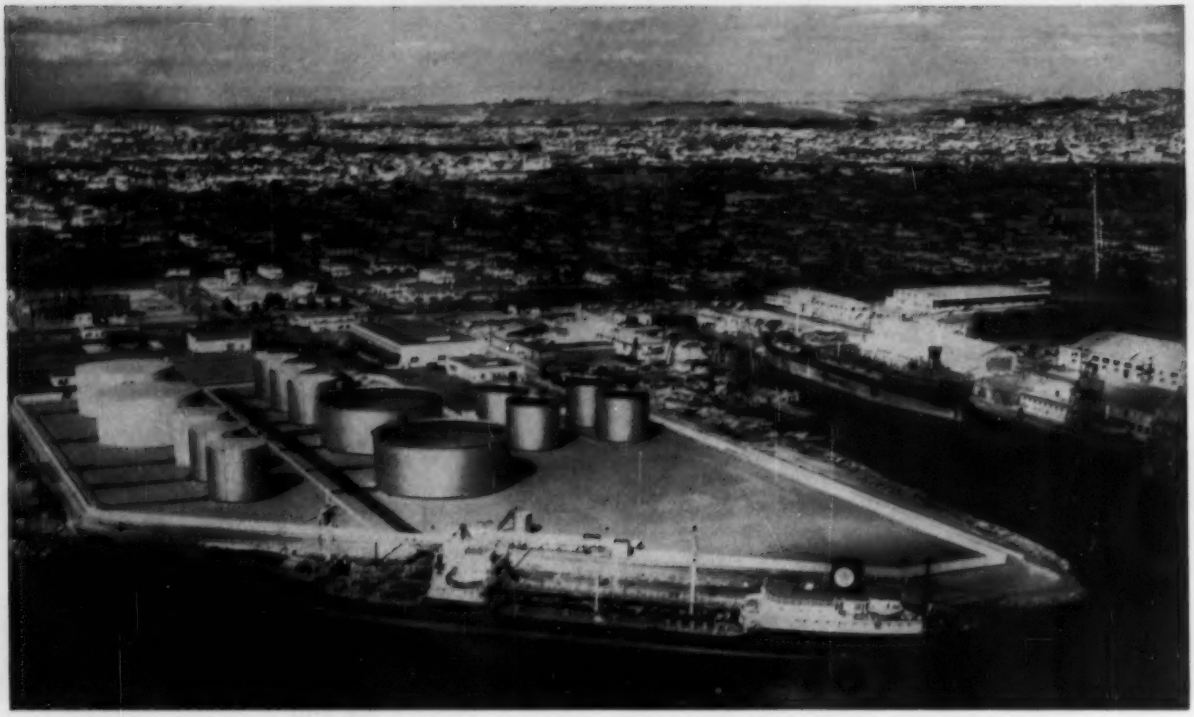


This new refining terminal, which replaces a terminal at Oakland, was completed by The Texas Company at Richmond, Calif., in January, 1955.

Texaco Doubles Refining Investment

In the 10-year postwar period company's crude charge capacity also has jumped from 417,400 to 577,000 barrels daily and high-octane facilities has been expanded more than five-fold.

THIS YEAR The Texas Company will complete a ten-year refinery construction program which will more than double its investment in refining equipment, and result in substantial increases in both manufacturing capacity and product quality. At the end of 1945 Texaco's refineries had a crude charge capacity of 417,400 barrels a day; today the capacity is 577,000 barrels a day.

While the postwar expansion in crude charge capacity has increased 38.2 percent, even greater gains had been made in manufacturing higher quality petroleum products. Texaco expects to produce more than 4 billion gallons of gasoline in 1955. This represents an increase of 55 percent in the postwar decade. Production of Texaco lubricating oil and other products have risen at about the same rate over 1945 figures.

When World War II ended, Texaco had three fluid catalytic cracking units, with a total capacity of 45,000 barrels a day. Today, it has ten catalytic crackers with an aggregate capacity of 193,000 barrels a day. Alkylation units for the production of aviation gasoline have been increased from six to nine units, with an increase in alkylate yield from 17,600 to 24,000 barrels a day. In the last two years, the company has completed nine catalytic reforming units, with a total capacity of 101,000 barrels a day. Thus in the postwar decade, Texaco has expanded its high-octane

producing facilities more than five-fold.

This expansion has been accompanied by a rise in Refining department personnel from 11,022 in 1945 to a present-day 13,586 employes. This figure is exclusive of research and technical personnel, who have recently been organized into a separate department.

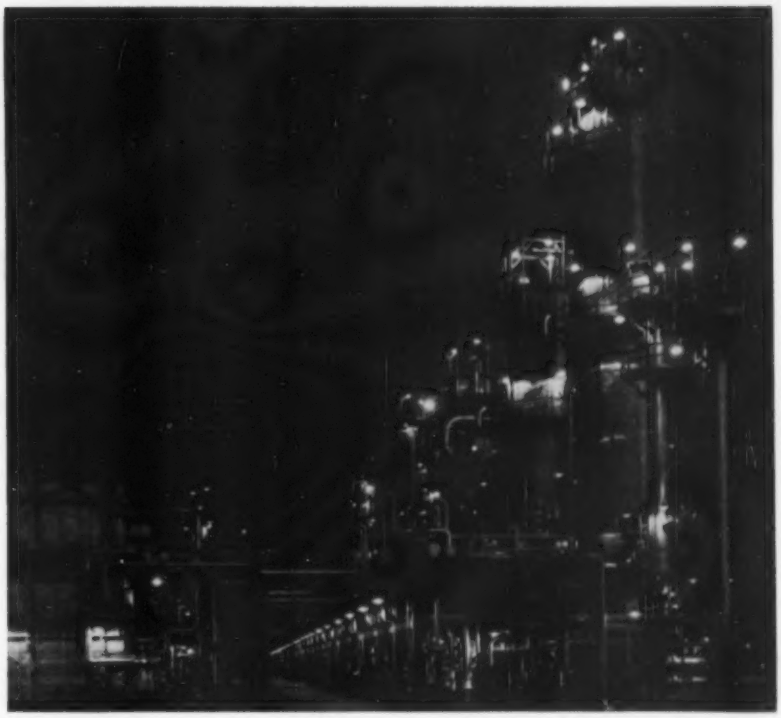
At the end of World War II, Tex-

This is another of a series telling of oil refining's tremendous postwar expansion. It's a continuing program, one that has kept management, engineering and construction forces in high gear. This month it's the Texaco story. Last month it was Caltex. In December, Gulf's activities will be detailed.

aco's management expected a rapid rise in demand for gasoline. The problem of expanding refining facilities was complicated by the fact that higher-octane motor fuels, as well as tougher lubricating oils, were required for the new high compression automobile engines which were coming on the market.

In 1945, the company had 18 refineries in the U. S. Because ten of these plants had capacities of 7500 barrels a day or less, plans were made for a complete realignment of the refinery organization. One reason for the decision to operate fewer and larger refineries was that in the manufacture of higher-octane fuels a large thruput is necessary to keep costs from becoming prohibitive. Another was that with the coming of product pipe lines, strategically-located refineries could efficiently serve larger territories.

Eight of the smaller refineries were eventually shut down and dismantled, the closings being synchronized with expansion programs at other plants, so that employes at the closed plants could be absorbed in the expanded units and, at the same time, markets could be kept supplied.



Two catalytic reforming units, with a combined capacity of 40,000 barrels daily, were completed at Texaco's Port Arthur Works in 1954 and 1955. One of the units is shown above.

The first step in the postwar program was the building of catalytic cracking units to meet the demands for higher-octane gasolines. New crackers were added to several refineries in the late 1940's. Today, ten of these units, with a total capacity of 193,000 barrels a day, are in operation.

During this period the 60,000 barrel-per-day Eagle Point Works, at Westville, N. J., was completed to serve East Coast needs. On the Delaware River opposite Philadelphia, the refinery ships gasoline, middle distillates and fuel oils by water, rail, and truck, and also is connected to the new Harbor Products Pipe Line which delivers products to the New York City metropolitan area for redistribution.

In the meantime, from 1946 through 1949, Texaco closed smaller refineries at Cody, Wyo.; Craig, Colo.; and Houston, West Dallas, and San Antonio, Texas. The refinery at Fillmore, Calif., was closed in 1950, and the plant at Calpet, Wyo., was closed down in 1952. Another small refinery at Pryse, Ky., was sold in 1945.

Concurrently, expansion and modernization programs were undertaken at Texaco refineries in Port Arthur, Texas; Lockport and Lawrenceville, Ill.; Los Angeles, Calif.; West Tulsa, Okla., and Casper, Wyo. In the past year, the Amarillo and El Paso, Texas, refineries have been practically rebuilt and greatly expanded.

In the last two years nine catalytic reforming units, with a total daily capacity of 101,000 barrels, have been built and placed in operation, and a tenth unit, at the Casper, Wyo., re-

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See **Texaco Growth**
Continued on Page 256

How to calculate . . .

Flashflow Pressure Drop in Heaters

Here's a simple and fast way to find the pressure drop in a heater tube with an evaporating fluid.

Frank L. Maker,
Standard Oil Company of California, San Francisco

CALCULATING PRESSURE drop in heater tubes with an evaporating fluid is usually done by trial-and-error methods. This is time consuming. Here is a discussion of methods available with an example of Ludwig's method. This example is a simple and fast way to compute pressure drop for pressures above atmospheric where velocity pressure effects are minor. A simple graphical way of integrating the pressure back from the known required conditions at the outlet including velocity effects, is developed for vacuum conditions.

The Simplest Case: All Liquid—When the fluid in a heater is not evaporating as it flows, the pressure drop can be computed in a simple manner, using an average density and an average friction factor. It will be convenient to express the flow rate in terms of mass flowing per unit time instead of volume rate in the following form:

$$p_1 - p_2 = \frac{3.36 \times 10^{-6} f M^2 L}{D^5 \rho}$$

where

p_1 = inlet pressure, psi
p_2 = outlet pressure, psi
M = Lb Mass/hr fluid per tube
D = Inside Diameter of Tube, inches
ρ = Average density of the fluid, Lb mass/Ft³
L = Length of Tube, Ft
f = Friction Factor

In this form the friction factor does not vary as the density changes. It does vary with change in viscosity, but because the friction factor varies with about the —0.2 power of Reynolds Number, a variation in viscosity of 32 fold is required to change the friction factor by a factor of 2. For ordinary pressures the effect of changing

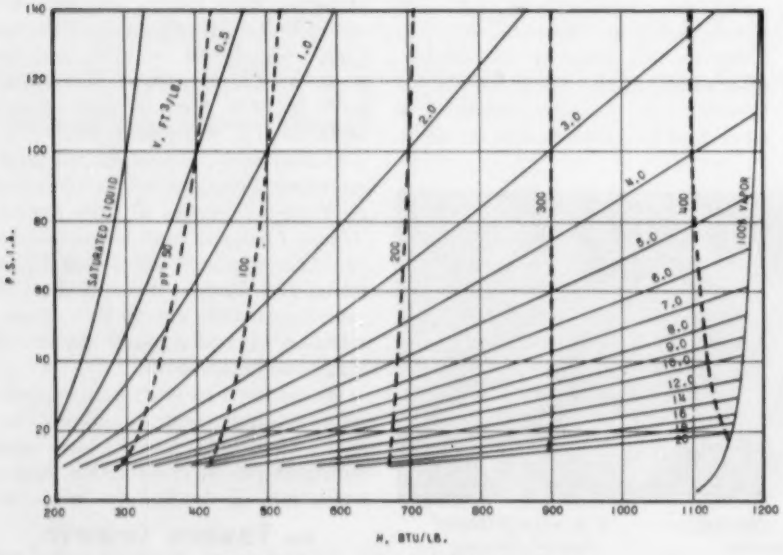

FIGURE 1—Pressure versus Enthalpy for steam.

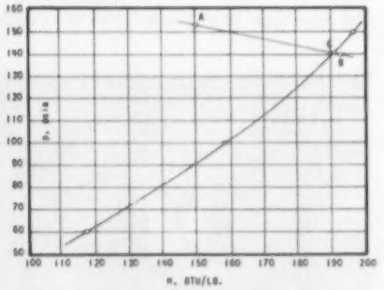

FIGURE 2—p versus H for crude petroleum along the bubble point line.

Meet the Author

FRANK L. MAKER has been with Standard Oil Company of California since 1916. He started with the company as a structural engineer, shortly after completing an architecture degree at the University of California, and since has served as designs engineer at Standard's Richmond, Calif., refinery; with the Manufacturing department, and as secretary of the company's board of consulting engineers. From 1942 to 1943 he was acting designs engineer for Arabian American Oil Company's Ras Tanura, Saudi Arabia refinery. He also holds a mechanical engineer's degree from the University of California and is registered in that state as a professional engineer in civil, mechanical and chemical engineering.

pressure in the tubes on the density of the liquid may be neglected.

What Is the Effect of Evaporation on Pressure Gradient?—When vaporization commences, the average density of the mixture rapidly decreases, and the velocity of flow correspondingly increases. The pressure gradient is directly proportional to the specific volume or inversely proportional to the density. At any point the density depends on the pressure and the enthalpy of the fluid at that point. The pressure at any point depends on the pressure at the outlet, plus the pressure drop from the particular point to the outlet. The point at which vaporization starts is not known. It is therefore necessary to start at the known conditions at the outlet and work backward to integrate the pressure drop.

The method that has commonly been used was to divide the tube length into sections. From a knowledge of the outlet pressure, temperature, and enthalpy conditions (which are set by the conditions the heater has to meet), and from the data on the pressure, temperature, enthalpy, and percentage vaporized, it is possible to compute the density of the mixture of liquid and vapor at the outlet. An estimate (or guess) is made of the pressure drop across the first section back from the outlet, and the pressure at that point determined. For this pressure, and its corresponding conditions of enthalpy and temperature, the density of the mixture at the inner end of the final section is computed. The average of this and the outlet density is then used to compute the pressure drop over the section. This is compared with the assumed pressure drop. If it does not agree, additional approximations are made until agreement is reached. When it does check, the process is repeated for a second small section, and so on,

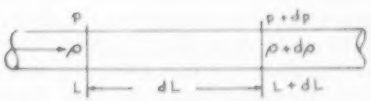

FIGURE 3—Graphical solutions notations.

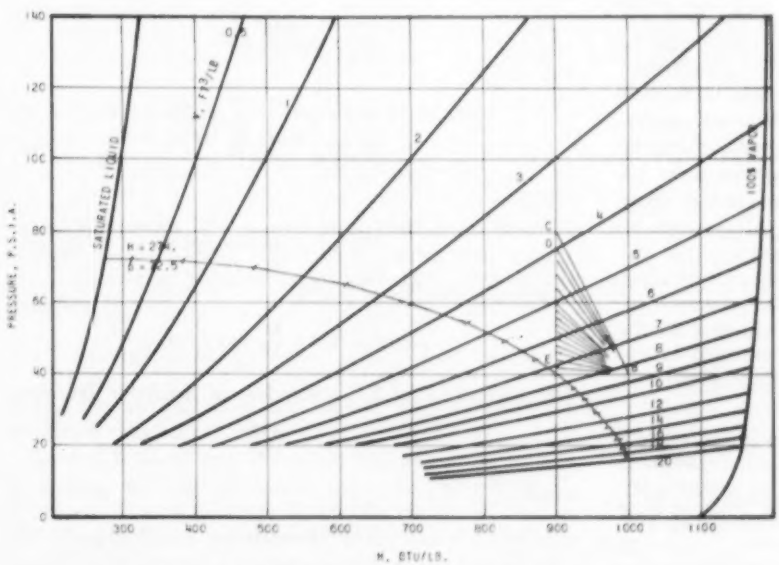

FIGURE 4—Graphical integration of p versus H curve of steam.

back to the point where density becomes equal to the liquid density, which is where vaporization starts.

It is obvious that this process is somewhat slow, although after some practice the first guesses will be better, requiring less trials.

Although this problem is one that has confronted all designers of tubular heaters, there has been very little information on it in the literature, in fact, practically nothing until the last few years. The most complete description of a computing method is that in the paper, "Pressure Drop of Oil-Vapor Mixtures in Furnace Coils," by Dittus and Hildebrand.[1] In this article the problem is outlined, and the method of determining the specific volumes of the liquid-vapor mixture is described. It is then noted that lines of dp/dL at constant p are approximately linear with respect to L, and a family of these lines can be constructed. Each point on a line for a given value of p represents the rate of pressure decrease with respect to length that will occur in the portion of the line where the pressure is equal to the chosen value of p. Using these slope lines as guides of the magnitudes, an estimate is made of the value of the pressure in a small section of length dL back from the outlet and an average value of dp/dL over this section is taken. Then

$$-\frac{dp}{dL} \times dL = -dp.$$

In other words, the pressure drop of the section dL is equal to the product of dL and the average value of dp/dL chosen, or to the area under the curve of p vs. L. This can be evaluated graphically or arithmetically, and the value compared with the assumed value. If the results are plotted on the sheet having the lines of $(dp/dL)_p$, the line of pressure drop found will guide the selection of the next value to a closer approximation.

While this is essentially still a cut and try process, it is done in an orderly way in which the results already found assist in guiding the next step.

Dittus and Hildebrand also note that if the heat absorbed per unit length of tube is constant, which may be assumed for the case of tubes absorbing heat by radiation, H, the enthalpy of the fluid, is proportional to L, and that dp/dH may be substituted for dp/dL to advantage. They give an equation for determining the value of dp/dH as a function of H that includes not only the friction pressure drop, but also that for velocity head and for elevation. For horizontal tubes, the last can be neglected. They state that in their experience the velocity head effect has not been important as compared with friction and that ordinarily adding the velocity pressure corresponding to the final velocity will give results sufficiently accurate. (It may be noted here that in the case of vacuum operations, where the velocities may be very high, this will not apply.)

Although this method is a considerably more orderly approach to the problem, and not too difficult when it has been grasped and is fresh in mind, it is still quite formidable and will require some hours of study and trial to apply it when it is not used frequently.

As a part of a Defense Course in 1944 on "Hydraulics of Pipe Lines," M. Ludwig includes the derivation of the formula for isothermal flow of a perfect gas.[2] This is based on the fact that for a perfect gas

$$pV = nRT = \text{constant}$$

which permits ready integration of the pressure drop differential equation. He includes provision also for taking care of deviation from the gas law, but the most important part of his notes, as far as concerns the present subject of pressure drop in furnace tubes, is a section dealing with flow of gases and liquids being heated, which can be integrated if pV is linear with respect to H. This development is given in detail below.

A paper by Baars[3] in J.I.P.T. discusses "Vaporization in Furnace Tubes." This is principally a discussion of furnace design, and the portion dealing with the method of computing the pressure drop indicates the use of the conventional step-by-step computation back from the outlet, and contributes no advance to this subject.

Ludwig's Method for Flow While Heating—Let us now make a more detailed review of Ludwig's proposal. Consider first the case of gas flowing in a pipe. The pressure drop due to friction can be expressed in differential form as follows:

$$dh = -\frac{u^2}{2g\,D} f dL$$

or

$$dp = -\frac{u^2 \rho}{2D} f dL \qquad (1)$$

where the quantities are in consistent units, such as

p = poundals/ft.^{2}
u = Ft/sec.
D = Ft
L = Ft

If the flow rate is expressed in Lb mass/sec

$$u^2 = \frac{16M^2}{\pi^2 D^4 \rho^2}$$

and we arrive at

$$dp = -\frac{16M^2}{2\pi^2 D^5 \rho} f\, dL$$

or

$$dp = -0.811 \frac{M^2}{D^5} Vf\, dL \qquad (2)$$

where

$$V = \frac{1}{\rho} = \text{specific volume} = \text{ft}^3/\text{lb mass}.$$

Multiply both sides by p and

$$pdp = -0.811 \frac{M^2}{D^5} (pV) f\, dL \qquad (3)$$

The friction factor f is a function of Reynolds' Number,

$$Re = \frac{u D \rho}{\mu}$$

where

u = velocity, ft/sec

and

μ = absolute viscosity, lb mass/sec. ft.

if the flow is expressed in mass flow rate, the above form of Reynolds' Number becomes

$$Re = \frac{4M}{\pi D \mu}$$

where

M = Mass flow/unit time = lb mass/sec.

For steady state flow in a pipe of uniform diameter, M and D are constant, and the viscosity μ is not affected by pressure for a perfect gas, and is very little affected by temperature. Reynolds' Number is therefore practically constant. The friction factor f for smooth pipe is proportional to about the — 0.2 power of Reynolds' Number, so that a change of viscosity of 32-fold is required to change the friction factor by a factor of 2. For rough pipes, and where an appreciable proportion of the pressure drop is due to turbulence and shock losses, as in return bend headers, the friction factor approaches more closely yet to being constant.

For a perfect gas, pV is a constant at constant temperature, so for isothermal flow we may therefore integrate equation (3) to get

$$\frac{p_1^2 - p_2^2}{2} = 0.811 \frac{M^2}{D^5} (pV) fL \qquad (4)$$

Where

V = spec. volume = ft³/lb mass at the temperature of flow and at pressure p

$$p_1^2 - p_2^2 = 1.622 \frac{M^2}{D^5} (pV) fL \qquad (5)$$

The constant value of pV must be substituted in this equation, and all quantities are in consistent units.

Flow of a Gas Being Heated—Now consider the case of gas being heated as it flows. Assume the heat absorbed per linear foot of tube is constant. The enthalpy H of the gas will then increase linearly with the length passed through. If the specific heat may be taken as constant over the range in question, T will vary linearly with L, and so will pV = RT.

In the differential equation

$$pdp = \frac{-0.811\, M^2}{D^5} (pV)\, f\, dL, \qquad (3)$$

pV is therefore linear with respect to L, so that

$$\int_{L_1}^{L_2} (pV)\, dL = \frac{(p_1 V_1) + (p_2 V_2)}{2} (L_2 - L_1)$$

or, in other words, the integral of (pV) dL from L_1 to L_2 is equal to the average value of pV times the interval $(L_2 - L_1)$. The pressure drop over this interval will therefore be

$$p_1^2 - p_2^2 = 0.811 \frac{M^2}{D^5} (p_1 V_1 + p_2 V_2)\, f\, (L_2 - L_1) \qquad (6)$$

(This development does not include any provision for velocity head effects.)

In the ordinary case the conditions at the outlet will be known, and also the length $(L_2 - L_1)$, so that $p_2 V_2$ is known. The value of $p_1 V_1$ can be computed also, as pV is taken linear with respect to L, and the enthalpy condition at the end is known, as well as the rate of heat absorption per foot length. This permits solution for p_1.

Pressure Drop With An Evaporating Liquid—In the case of an evaporating fluid, for which also pV is not constant, equation (6) suggests comparing pV with H to see whether a similar relation holds for a liquid-vapor mixture, that is, whether pV varies linearly with H, and therefore with L. The easiest way to test the matter is to use a material for which comprehensive data on the properties are available, which is water. Data were therefore taken from Keenan and Keyes, "Thermodynamic Properties of Steam,"[5] for the range of 10 pounds per square inch absolute to 140 psia.

With H as abscissa and p as ordinate, the limiting curves of p vs. H for saturated liquid and saturated vapor are plotted. Then values of constant V are plotted and across these are lines of constant values of pV, in this case for values of pV = 50, 100, 200, 300 and 400. (Figure 1.)

If pV is linear with respect to H, it would be independent of p. This means that the lines of constant pV would be vertical. They would also be spaced at equal intervals of H. It will be noted that in the interval above about 50 psig, the lines do not deviate too markedly from the vertical, and that along the line of 100 psia pressure, they are spaced evenly at the rate of 0.5 ft³/lb per 100 Btu/lb. In this range, we may then consider that pV is linear with respect to H, and therefore the same type of equation will hold for the evaporating water as for a gas being heated, or

$$p_1^2 - p_2^2 = 0.811 \frac{M^2}{D^5} (p_1 V_1 + p_2 V_2)\, f\, (L_2 - L_1) \qquad (6)$$

All in consistent units.

If p is expressed in psi, M in lb mass/hr, and D in inches, this becomes

$$p_1^2 - p_2^2 = 3.36 \times 10^{-6} \frac{M^2}{D^5} (p_1 V_1 + p_2 V_2)\, f\, (L_2 - L_1) \qquad (7)$$

Although the equation is of the same form as for a gas being heated, the relation of $p_1 V_1$ to length is not the same, since $p_1 V_1$ for an evaporating liquid does not have its zero value at zero temperature. It is necessary to determine the values of $p_1 V_1$ from the physical properties of the liquid and its vapor, for each fluid.

The fluid used above was water, because ample accurate data are available in the steam tables to prepare the chart of Constant V on p vs. H. It is possible to apply this equation to other substances, including complex mixtures such as crude petroleum. For an example, take the case worked out in the paper of Dittus and Hildebrand, for which the following data apply:

Enthalpy at inlet	150 Btu/lb
Enthalpy at outlet	331 Btu/lb
Pressure at outlet	32 psia
Specific volume of liquid	0.026 ft³/lb mass
Specific Volume at outlet	1.39 ft³/lb mass

(Interpolated from Table 1 of Dittus and Hildebrand, for consistency.)

Total fluid 140,000 lb mass per hr in two parallel passes or M = 70,000 lb/hr per pass.

Length of tubes 27 ft. with 34 tubes in series. Total length 920 ft.

Inside diameter of tubes 4.5 inches

$4.5^4 = 1850$

Flashflow Pressure Drop in Heaters . . .

Equivalent length of return headers

$$34 \times \frac{4.5}{12} \times 50 \times 3 = 1910 \text{ ft.}$$

No. Tubes	Diam. in feet	Diams. per velocity head	Velocity heads per header

Total equivalent length 2830 ft.

$p_2^2 = 32^2 = 1024$
$V_1 = 0.026$ ft³/lb (assumed constant)
$V_2 = 1.39$ ft³/lb at outlet
$p_2 V_2 = 32 \times 1.39 = 44.5$
$M = 70{,}000$ lb/hr, so $M^2 = 49 \times 10^8$
$D = 4.5$ inches, so $D^5 = 1845$
$L_2 = 2830$ ft equivalent length
$f = 0.02$ (assumed constant)

The value of p_1 is missing, also that of L_1, p_1 being the pressure at which vaporization starts and L_1 being the length of tube from the inlet to the point where vaporization starts. There is available other information which will help tie down the solution. The Dittus-Hildebrand paper includes a curve of enthalpy vs. temperature, and a curve of pressure vs. temperature, and also the given conditions that the enthalpy of the liquid at the inlet is 150 Btu/lb and at the outlet 331 Btu/lb. The change in enthalpy is 331 — 150 = 181 Btu/lb, and the change in enthalpy per ft. equivalent length is 181/2830 = 0.064 Btu/lb ft. length.

With these items we may proceed with a trial and error procedure, which is, however, quite rapid.

Substituting the known quantities in equation (7) we get

$$p_1^2 - 1024 = \frac{3.36 \times 10^6 \times 70{,}000^2}{4.5^5} \cdot (p_1 V_1 + 44.5)\, 0.02 \cdot (L_2 - L_1) \quad (8)$$

The point of initial vaporization is not known. As a first approximation, assume vaporization starts at the inlet end and also that at this point the value of $p_1 V_1$ is small enough to be neglected. $(L_2 - L_1)$ will then be 2830 equivalent feet, and

$$p_1^2 = \frac{3.36 \times 10^{-6} \times 49 \times 10^8}{1845} \times 0.02 \times 44.5\ (L_2 - L_1) - 1024$$

$$p_1^2 = 7.94\ (L_2 - L_1) + 1024 = 7.94 \times 2830 + 1024 = 22{,}450 + 1024 = 23{,}474$$

whence

$p_1 = 153$ psia.

Now if our assumption is correct, this pressure should correspond to the boiling point pressure of the liquid when the enthalpy is 150 Btu/lb.

From the curves of pressure vs. temperature and enthalpy vs. temperature (Figures 4 and 3 in the Dittus-Hildebrand paper), we can take the following data and plot p vs. H along the boiling point line (Figure 2).

p psia	T °R	H Btu/lb above 520 R
15	615	45
30	615	74
60	750	117
100	820	158
150	880	196

The pressure p just found as a first approximation is 153 psia and the enthalpy at the inlet is given as 150. These coordinates are plotted as point A and are seen to fall above the boiling point line, indicating that the vaporization point has not yet been reached.

Assume another lower pressure, say 140 psig, and solve for the length $(L_2 - L_1)$ corresponding: (column III in Table 1).

TABLE 1

I	II	III	IV
	P1	140	141
a	P_1^2	19,600	19,881
b	$P_1^2 - 1024$	18,576	18,857
c	$p_1 V_1$	140 x 0.026 = 3.64	141 x 0.026 = 3.67
d	$p_1 V_1 + p_2 V_2$ ($p_2 V_2 = 44.5$)	48.14	48.17
e	$\frac{7.94}{44.5}$ x (d)	8.588	8.593
f	$(L_2 - L_1) = \frac{(b)}{(e)}$	2,163 ft.	2,194
g	$(L_0 - L_1) = 2830 - 2163$	667 ft.	636
h	Increase in H from L_0 to L_1 = 0.064 x (g)	42.7 Btu/lb	40.7
i	H at L_1	192.7 Btu/lb	190.7

Subtracting this length from 2830 gives the distance from the inlet L_0 to L_1 where vaporization starts, which is 667 feet. Since the change in enthalpy is 0.064 Btu/ft, the change in 667 ft. will be 42.5 Btu/lb, which added to the enthalpy of 150 Btu/lb at the inlet gives 192.5 Btu/lb. Plotting (192.5, 140) as point B, it is seen to fall on the other side of the p, H curve, but so close that a graphical interpolation will give the answer as p = 141 psi and H = 190.5 Btu/lb. However, for purposes of illustration, carry this assumption through. These figures are in Column IV of Table 1 and indicate that for p = 140, H = 190.7, which lies on the curve.

The pressure drop of the non-vaporized liquid from the inlet to L, where vaporization starts, will be

$$p_0 - p_1 = 3.36 \times 10^{-6} \frac{M^2}{D^5} \times 0.026 \times 0.02 \times 636 = 2.95 \text{ psi}$$

Adding this to the 141 psia pressure in the section where vaporization takes place gives a total pressure at the inlet of 144 psia as against the 144.6 worked out in the Dittus-Hildebrand example.

The above method also neglects the velocity head effect, but for this example the velocity pressure at the outlet is only 4.65 psi and this amount can be added to the friction loss to give an answer close enough. The total inlet pressure would then be, by Ludwig's method, 148.65. This is about 10 psi higher than the test data quoted by Dittus and Hildebrand. A small change in the value of the friction factor assumed would take care of this.

This example shows that Ludwig's method gives the same result as the Dittus-Hildebrand method, and is very much quicker. It requires only a knowledge of the value of $p_2 V_2$ at the outlet, the liquid specific volume, and a curve of p vs. H, which can easily be constructed from a Cox chart of vapor pressure and a temperature-enthalpy chart.

It has a limitation, however, which is embodied in the basic assumption that pV is linear with respect to H. This was found not to hold for low pressures for steam and also does not hold for examples for which it has been tried for low pressure (vacuum) distillation of petroleum residuum. In these low pressure cases, furthermore, velocities become high and velocity head effects, and even critical flow rate limits, become important. The following paragraphs discuss this problem, and also a graphical means of solving it that is simple in application.

How to Handle the Variable Density Case—Consider a short section dL of pipe at point L in the length between L_1 and L_2. The pressure at the upstream end of this section is p poundals per square foot. The flow rate is M Lb/sec., the inside diameter is D ft and the density of the fluid is ρ lb mass/ft.^{3} with corresponding specific volume V ft.^{3}/lb mass. The velocity head at L is

$$h = \frac{u^2}{2g}$$

and the velocity pressure at L is

$$h\rho g = p = \frac{u^2\rho}{2} = \frac{M^2V}{2A^2}$$

At L + dL the specific volume will be V + dV and the velocity pressure will be

$$\frac{M^2 (V + dV)}{2A^2} .$$

There will be a loss of pressure in the section dL because of friction, that will be equal to

$$dp = \frac{-u^2 \rho f\, dL}{2D} = \frac{-M^2 V f\, dL}{2DA^2}$$

The conditions are therefore as follows:

$$\text{At L,}\quad p + \frac{M^2V}{2A^2} = p^* \qquad (9)$$

Static Pressure — Velocity Pressure — Total Pressure

At L + dL,

$$p + dp + \frac{M^2 (V + dV)}{2A^2} + \frac{M^2V f\, dL}{2DA^2} = p^* \qquad (10)$$

Subtract (9) from (10) and we get

$$dp + \frac{M^2dV}{2A^2} + \frac{M^2 V f\, dL}{2DA^2} = 0 \qquad (11)$$

Consider now the effect of adding heat along the tube. In the radiant section of a heater, which is usually where the evaporation takes place, it may be assumed that the heat absorption per square foot of tube surface will be sensibly uniform, since the rate of heat absorption, according to the Stefan-Boltzman Law is, in the temperature ranges usually encountered in industrial furnaces, very little affected by the temperature of the tube wall. Let this radiant heat absorption rate be Q Btu/sec ft.^{2} of internal tube surface. (The absorption rate or heat flux is usually given in terms of the external surface, but this can easily be transformed for a given tube.) If the inside tube diameter is D ft, the heat absorption rate per linear foot will be

$$Q\pi D \text{ Btu/sec ft.}$$

If M lb/sec are flowing through the tube, the change in enthalpy in dL feet will be

$$dH = \frac{Q\pi D\, dL}{M} \qquad (12)$$

whence

$$dL = \frac{M}{Q\pi D} dH \qquad (13)$$

Making this substitution in (11)

$$dp = -\frac{M^2dV}{2A^2} - \frac{M^2 V fM\, dH}{2A^2 DQ\pi D} \qquad (14)$$

Since $A = \pi D^2/4$, this further reduces to

$$dp = -\frac{8M^2\, dV}{\pi^2 D^4} - \frac{8M^3 Vf\, dH}{\pi^2 D^5 Q} \qquad (15)$$

or

$$dp = -\frac{0.811\, M^2\, dV}{D^4} - 0.258\, \frac{M^3 Vf\, dH}{D^5 Q} \qquad (16)$$

(all in consistent units).

This cannot be integrated directly since it contains the quantities V and dV, and the relation of V to p and H is not known analytically. (See Figure 4.)

The first term on the right-hand side gives the change in velocity head with change in the specific volume. For the time being, consider that we have such conditions that this can be neglected. Then we write

$$\frac{dp}{dH} = -\frac{0.258M^3 Vf}{D^5Q} \qquad (17)$$

At the outlet end of the heater we know H, p, and M, as well as D and Q and f, and therefore can compute the value of dp/dH at the outlet.

If we have a plot of specific volumes on a p vs. H coordinate system, such as Figure 1 for steam, we know the slope of the p vs. H curve at the outlet, and on this plot the line will slope upward toward the left. We do not yet know what other points the curve passes through, but we do know that as it passes upward to the left, it will successively cut different lines of constant specific volume. If each value of specific volume V is substituted in (17), we will have the slope at which the p vs. H curve crosses the particular line of constant V. If across each such line of V we draw a series of short parallel lines of the corresponding slope, and if the lines of constant V are reasonably close together, the eye will be led back naturally in a curve which will be the p vs. H curve, to the limiting line of saturated liquid. This line can readily be sketched in, and the pressure and enthalpy at the point where vaporization starts can be determined.

This is exactly the means of solving a differential equation that is suggested in Fry's "Differential Equations"[6] and also in "Mathematical Methods of Engineering," by Karman and Biot[7] in explaining the significance of the integral curve of a differential equation. Karman and Biot call it the "isocline method." It is also discussed, though not illustrated so clearly, in "Higher Mathematics for Engineers and Physicists," by I. S. and E. S. Sokolnikoff.[8]

This method is illustrated in Figure 4 which is plotted on the grid of p vs. H for steam (Figure 2). For this case the following conditions were assumed:

At outlet

$p_2 = 16.5$ psia
$H_2 = 1{,}000$ Btu/lb
$f = 0.02$
$M = 14{,}725$ lb/hr
$Q = 10{,}000$ Btu/hr ft.^{2}
$D = 4''$
$V_2 = 20$ ft.^{3}/lb mass

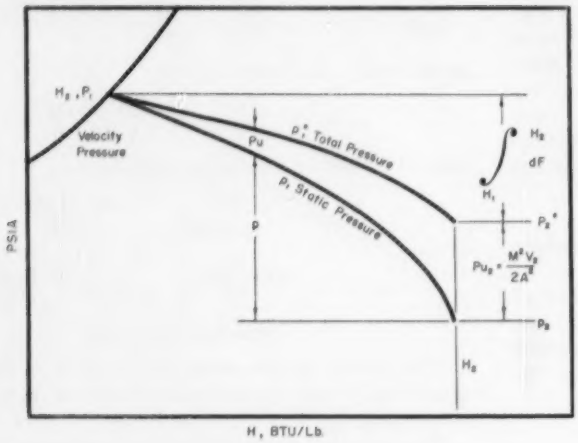

FIGURE 6—Static pressure, velocity pressure, and total pressure along the tube.

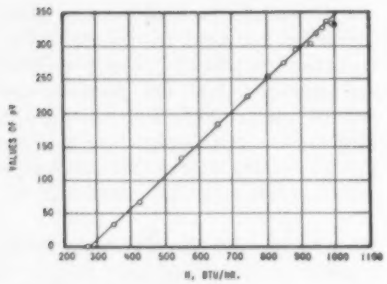

FIGURE 5—pV versus H for steam along path of pressure.

Before proceeding, it will be convenient to change (17) from the consistent units to the more common inconsistent units as follows:

p	psi
D	inches
L	Ft
H	Btu/lb mass
M	Lb mass/hr
Q	Btu/hr ft²
V	Ft³/lb mass

to get

$$\frac{dp}{dH} = -\frac{12.832 \times 10^{-9}\, M^2 f V}{D^5 Q} \qquad (18)$$

The graphical integration is carried out on Figure 4. This is a copy of Figure 1, the chart of p vs. H for steam on which values of constant specific volume V are plotted. Start at point A on Figure 4 for the value of H = 1000, p = 16.5 psia, and V = 20 ft³/lb mass. The slope of the p vs. H curve at this point is, from Equation (18)

$$\frac{dp}{dH} = -\frac{12{,}832 \times 10^{-9} \times 14{,}725^2 \times 0.02 \times 20}{4^5 \times 10{,}000} = 0.40 \text{ psi/Btu} \qquad (19)$$

At a convenient point on the chart a line of this slope can be drawn. This is line BC. In this case the line runs upward 40 psi and to the left 100 Btu. A short line through "A" parallel to this line B C starts the curve.

The curve will necessarily cut the next line of constant volume, which on this chart is for 18 ft³/lb mass. Now the slope of the curve where it crosses the 18 ft³/lb could be computed from Equation (18) but this is not necessary. If we draw a vertical line CE downward from a point C on line BC where it is 20 convenient units higher than B, then this vertical line can be used as a scale to draw slopes corresponding to the successive values of V. For example:

BC has a slope 40/100 and V = 20
BD has a slope 36/100 and V = 18

and so on. Actually the lines BC and CE are the only ones that need to be drawn. The other slopes can be read off and transferred by a triangle without drawing the lines through B.

Through the line of V = 18 we could draw a number of short parallel lines of slope 0.36 and through V = 16 a number of slope 0.32, and then by eye sketch in the curve so that it would cross each line of constant V at the slope of these short slope lines. Actually, where the lines of V are close together this is not necessary. The line from A is extended to a point half-way between V = 20 and V = 18. Then from this point a line of slope 0.36 (appropriate to V = 18) is extended to a point half-way between V = 18 and V = 16, and so on, This in effect assumes that the tangents to the curve intersect half-way between the lines of constant V, which is good enough when the lines are close together and the curvature is not changing rapidly. Where the curvature is changing rapidly, the intersection will be closer to the line where the curvature is greater. The difference can be made much less than other uncertainties, such as the value of the friction factor, the variation of actual pipe diameter from nominal, the decrease of diameter due to scaling or coking, etc.

Following this procedure, we arrive at the liquid saturation line at

p = 72.5 psia
H = 275 Btu/lb mass.

The effect of a change in the mass flow rate can be computed quickly, as this will change the initial slope, and the remainder can be sketched in quickly. Similarly the effect of changes in tubing size can be readily computed.

In the above no provision was made for return headers, and the result would apply for a continuous pipe. Headers may be allowed for by adding an equivalent length. This requires reducing the value of Q correspondingly so that in effect the same heat is spread over the equivalent length. Alternatively, the friction factor f can be increased to take care of the losses through the headers.

The heat absorption in this case was given as Q = 10,000 Btu/ft² hr. and the pipe diameter was 4 inches = 1/3 ft. We had

$$H = \frac{Q \pi D L}{M}$$

so

$$H = \frac{10{,}000\, \pi \times \frac{1}{3} L}{14{,}725} = 0.711\, L \qquad (20)$$

or

$$L = 1.406\, H$$

The total change in enthalpy from outlet to the point where evaporation starts is

$$H = 1{,}000 - 275 = 725 \text{ Btu.}$$

Whence

$$L = \frac{725}{0.711} = 1{,}020 \text{ ft.} \quad (31)$$

It will be of interest now to compare the result of this method with that obtained by Ludwig's method. Ludwig's equation (9) is

$$p_1^2 - p_2^2 = 3.36 \times 10^{-6} \frac{M^2}{D^5} (p_1 V_1 + p_2 V_2) f (L_2 - L_1) \quad (9)$$

This can be compared most simply by substituting the values of p_1, p_2, V_1, V_2, D, f and $(L_2 - L_1)$ in the above and solving for M. (V_1 for the water is 0.0175.) Doing this

$$M^2 = \frac{(72.5^2 - 16.5^2) \times 4^5}{3.36 \times 10^{-6} (16.5 \times 20 - 72.5 \times 0.0175) (0.02) (1020)} \quad (22)$$

$$= 226{,}000{,}000$$

$$M = 15{,}035 \text{ lb/hr.} \quad (23)$$

The difference between this and the value of 14,725 assumed for the other method is about 2 percent, which may be regarded as checking as close as could be expected.

What About the Velocity Pressure at Outlet?—The velocity pressure at the outlet is

$$p_u = \frac{M^2 V}{2A^2} = \frac{16 M^2 V}{2 \pi^2 D^4}$$

$$= 0.811 \frac{M^2 V}{D^4}$$

in consistent units.
This becomes

$$p_u = 0.28 \times 10^{-6} \frac{M^2 V}{D^4} \quad (24)$$

when

M = lb mass/hr
V = ft^3/lb mass
D = inches

For the conditions of this example, the velocity pressure at the outlet is

$$p_u = \frac{0.28 \times 10^{-6} \times 14{,}725^2 \times 20}{4^4}$$

$$= 4.75 \text{ psi} \quad (25)$$

This could be added to the pressure of 72.5 psia found for the point where evaporation starts to give

p = 77.3 psia total at that point.

The velocity pressure of 4.75 psi is about 8.5 percent of the total pressure drop, and this method of correction is close enough for this case.

For the cases where velocity head is not large and pV is reasonably linear with respect to H, Ludwig's method is the quickest, and is as accurate as the usual step-by-step method or the graphical method developed above.

As a further matter of interest, the values of p where the pressure curve of Figure 4 crosses each line of V were picked off and the values of pV were computed. These are plotted on Figure 5 and show that pV is linear with respect to H along the line of integration closer than the accuracy of plotting and reading permit checking. This justifies the use of Ludwig's method for this case.

The Complicated Case cannot be neglected: Let us now consider a case for which the velocity pressure is not small relative to the total pressure drop. Return to Equation (16).

$$dp + \frac{0.811 M^2 dV}{D^4} + \frac{0.258 M^2 V f dH}{D^5 Q} = 0 \quad (16)$$

Integrating,

$$p + \frac{0.811 M^2 V}{D^4} + \frac{0.258 M^2 f \int_{H_1}^{H_2} V dH}{D^5 Q} = \text{Const.} \quad (26)$$

In the above

p is the static pressure at any point.

The second term is the velocity pressure at any point or

$$p_u = \frac{0.811 M^2 V}{D^4} \quad (27)$$

The third term is the integrated loss of pressure due to friction from the point where vaporization starts (the bubble point) to any point corresponding to enthalpy H.

From the fact that at the bubble point the specific volume V is negligible, the second and third terms are negligible there, so the value of the constant on the right-hand side is therefore equal to the pressure at the bubble point, or p_1.

The sum of the static pressure p and the velocity pressure p_u is called the "total pressure." Equation (26) merely says that at any point the static pressure is equal to the initial pressure p_1, less the velocity pressure p_u and less the total friction pressure loss up to that point. The situation may be illustrated as in Figure 6 on the following page.

Equation (26) cannot be evaluated as was done for the previous case of Equation (17) because of the presence of the velocity pressure term. From Equation (27) it will be noted that the magnitude of the velocity pressure at any point, for a given flow rate and diameter, is proportional to the specific volume and is therefore constant along any line of constant specific volume. This suggests that a suitable change of variable may produce an equation in a form similar to the case where the velocity pressure was omitted, and that will permit a graphical integration:
Let

$$P + \frac{0.811 M^2 V}{D^4} = p^* \quad (28)$$

p^* is the sum of the static pressure and the velocity pressure, which is called, the "total pressure."

At the point where evaporation starts, the specific volume of the liquid is so small relative to that of the vapor formed that it may be neglected. Consequently, at this point the velocity pressure is negligible, and we can write

$$p^* = p = p_1 \quad (29)$$

At the outlet, where p_2 and V_2 are known

$$p^* = p_2 + \frac{0.811 M^2 V_2}{D^4} \quad (30)$$

Flashflow Pressure Drop in Heaters . . .

At any intermediate point the relation of p* and p is that indicated by Equation (28).
Equation (26) can now be rewritten as

$$p^* + \frac{0.258\ M^2 f \int_{H_1}^{H_2} V dH}{D^5 Q} = p_1 \qquad (31)$$

This requires evaluation of the integral $\int_{H_1}^{H_2} V dH$ for solution, which cannot be done directly because V is a function of both p and H, for which, in general, we have no analytical expression. We can put (31) back into the differential form:

$$dp^* + \frac{0.258\ M^2 f\ V dH}{D^5 Q} = O. \qquad (32)$$

Whence

$$\frac{dp^*}{dH} = -\frac{0.258\ M^2 fV}{D^5 Q} \qquad (33)$$

This is in the same form as the expression obtained for dp/dH for the case where velocity pressure is neglected. (See Equation 17). We can therefore compute the slope dp*/dH of the p* curve on the p vs. H grid for the outlet conditions, since we know the value of p_2 and H_2 at this point: and, by plotting the point, can determine the value of v_2, the specific volume of the mixture at the outlet. The values of constant V are determined by the static pressure p and the enthalpy H, and we now have to integrate, not in terms of p, but in terms of p*. However, Equation (28)

$$p^* = p + \frac{0.811\ M^2 V}{D^4} \qquad (28)$$

gives the relation between p* and p, and also says that along any line of constant V, the difference of p* and p is constant. This suggests that if for each line of constant V we draw another line V* which is higher than V by the value of the velocity pressure

$p_v = \frac{0.811\ M^2 V}{D^4}$, we will have lines of V* which bear the same relation to p* that the lines of V bear to p. Having drawn these lines of V*, we can then integrate graphically as before.

This shifting of the lines of V to V* does not, strictly speaking, constitute a transformation of axes of coordinates. This is evident from the fact that any line of constant p will cut several lines of constant V, and the velocity pressure correction for each line is different. It is true, however, that where the curve of p* crosses each line of V*, the correction for velocity pressure is made correctly, and these are the only points we are interested in.

To illustrate this method, an example will be worked out for a heater on a crude petroleum distillation column operating at low absolute pressure. The heat and material balance for the column has been determined and it is assumed that the pressure drop through the transfer line has been computed, so that the conditions at the outlet of the heater are as follows:

Flow of Inglewood Residuum

$M = 40{,}025$ lb/hr
$H_2 = 391$ Btu/lb
$p_2 = 2.45$ psia
$V_2 = 2.50$ ft³/lb

Tube Length 36 ft.

O.D. 6⅝", 0.2" wall thickness, I.D. 6.225"

$Q_o = 10{,}000$ Btu/hr. ft² on external area of tube

$Q_i = 10{,}000 \times \frac{6.625}{6.225} = 10{,}640$ Btu/hr. ft² on basis of internal area of tube.

The fluid being heated is a residuum that has already passed through one heater and has been flashed at slightly above atmospheric pressure, and is now being heated again under vacuum conditions to further reduce the residuum.

In order to plot the curve of p vs. H, some specific physical data are required. This was furnished by laboratory analysis of the residuum with the following results:
Stock 10.4° A.P.I. Residuum, representing 48% of a crude petroleum from a crude from Inglewood, California.
U.O.P. k value 11.5.

An equilibrium distillation run at 100 mm Hg absolute (1.94 psia) was available. This included determinations of the molecular weight of the vapor, from which the specific volume of the vapor could be computed.

From this curve and a Cox Chart of vapor pressure vs. temperature Table IA was computed, giving values of p vs. T for various constant values of fraction vaporized. This was plotted and from this chart and curves of enthalpy vs. temperature for crude petroleum of 11.5 K value, Table II of p vs H of the mixture was computed, and from the latter a chart (Figure 7) of p vs. H for various fractions vaporized.

TABLE 1A—10.4° API Inglewood Residuum

Equilibrium Flash Distillation at 1.94 psia (100 mm Hg.)

Percent Vapor	°F.	Molecular Weight of Vapor
0	630	
5	654	291
10	680	296
15	690	300
20	725	306

p vs. T for Various Percents Vaporised

Percent Vapor	0	5	10	20
psia.	°F.	°F.	°F.	°F.
1.0	580	596	627	665
1.5	616	630	660	696
2.0	636	655	693	722
3.0	672	692	722	760
4.0	702	722	752	788
5.0	728	745	773	810

(A line for 15 percent Vapor was interpolated in plotting this.)

The specific volumes of the vapors were then computed by the relation

$$\text{Specific Volume } V = \frac{359}{M.W} \times \frac{14.7}{p} \times \frac{T}{492} = 10.72 \frac{T}{p \times M.W}$$

	(a)	(b)	(c)	(d)
% Vapor		$\frac{10.72}{291}\frac{T}{p}$	$= 0.0370\ \frac{T}{p}$	(c) $\times 0.05 = 0.00185\ \frac{T}{p}$
5		$\frac{10.72}{296}\frac{T}{p}$	$= 0.0363\ \frac{T}{p}$	(c) $\times 0.10 = 0.00363\ \frac{T}{p}$
10				
15		$\frac{10.72}{300}\frac{T}{p}$	$= 0.358\ \frac{T}{p}$	(c) $\times 0.15 = 0.00537\ \frac{T}{p}$

$$20\,\frac{10.72}{306}\,\frac{T}{p} = 0.3505\,\frac{T}{p}\,(c) \times 0.20 = 0.00701\,\frac{T}{p}$$

These, multiplied by the fraction vaporized, will give the volume of the vapor from one pound mass of the residuum.

The specific volume of the liquid at 600F is 0.0197 ft^3/lb and at 700 F. is 0.0208 ft^3/lb. Assume an average value of 0.02 ft^3/lb.

The computations and values of the specific volumes are found are given in Table 3.

The lines of constant percent vaporized were plotted on a grid of p vs. H in Figure 7 and on these lines the various values of specific volume computed in Table III were marked, and by graphical interpolation, lines of constant specific volume V were plotted.

In the development of the method, consistent units have been employed. It is more convenient in working out the example to use the more common inconsistent units, as follows:

p = Lb. force per square inch
M = Lb. mass/hr. flow rate
Q = Btu/hr ft^2 heat absorbed by tube.
(Specify whether external or internal area basis)
D = Inches inside diameter of tube

The other units remain

p = Lb. mass/ft^2
V = Ft^3/lb mass
L = Ft

On this basis Equation (16) becomes

$$dp = -\frac{0.280 \times 10^{-4}\,M^2 dV}{D^4} - \frac{12{,}832 \times 10^{-9} M^2 f\,V\,dH}{D^5 \times Q} \qquad (34)$$

The velocity pressure in these units becomes

$$p_v = \frac{0.280 \times 10^{-4}\,M^2 V}{D^4} \qquad (35)$$

In an actual tubular heater, the flow resistance involves two elements, one being the frictional resistance of the tube walls and the other being the losses at the return bends, which are largely velocity pressure losses. There are two ways to take the return bend losses into account. For heaters and stocks in which the evaporation takes place over a considerable length of the tube, involving many return bends, the easiest way is to compute the equivalent length of the return bends and add it to the length of the tubes. This gives a total equivalent length of tubes and headers. The ratio of this total equivalent length to the actual tube length is computed and is inserted in the expression for the pressure drop per unit length. This is the method used in the Dittus-Hildebrand paper[1] and in the comparison by Ludwig's method above (Equation 22 and 23). In effect it increases the friction factor to take care of the losses at the return bends.

Where, however, the length of tube in which evaporation is taking place is small, the velocity pressure losses in the return bends may be relatively large and this method might not be satisfactory. In this case the graphical integration can be carried back one tube length, using the friction factor appropriate to the tube, and then a jog may be made equivalent to the pressure loss in the return bend and the graphical integration carried back another tube length until it is evident that the results would be practically the same by averaging the return

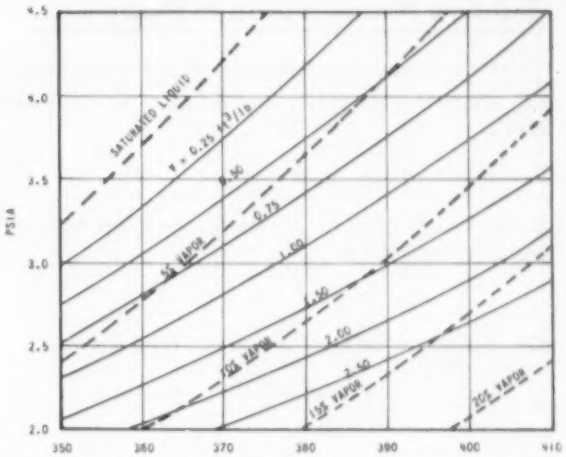

FIGURE 7—p versus H for Constant V, 10.4 Inglewood Crude.

bend losses with the friction. In the particular example, preliminary computations had shown that evaporation extended only about two tube lengths back. For purposes of comparison, the integration will be made first on the basis of considering the return bend losses distributed along the tube, and then an integration will be made on the basis of taking the header loss separately as a lump for each tube length.

On the chart of p vs. H it is possible to mark off the tube lengths for a given tube diameter, by using the relation from Equation (12)

$$H = \frac{\pi\,DQ}{M}\,L$$

where H is the change in enthalpy of the mixture flowing through the tube per foot length. For the present example we were given that

Q = 10,000 Btu/hr ft^2 of external area

This may be corrected to the basis of internal area by multiplying by the ratio of outside to inside diameters, thus

$$Q_i = 10{,}000 \times \frac{6.625}{6.225} = 10{,}640 \text{ Btu/hr ft}^2 \qquad (36)$$

Then, for a 36 ft. tube

$$H = \pi \times \frac{6.225}{12} \times \frac{10{,}640 \times 36}{40{,}025} = 15.6 \text{ Btu/lb} \qquad (37)$$

For values of f, the value of 0.02 used by Dittus and Hildebrand appears to be somewhat on the low side, and a value of 0.025 looks more reasonable. However, the over-all equivalent length they obtained by using f = 0.02 and 3 velocity heads per return header appears to be about right, so if this value of f is changed, the value of 3 velocity heads per return bend will also have to be changed. As long as the ratio of tube diameter to length in different heaters is about the same, a correct over-all figure (which is, of course, the thing than can be checked most easily by test data) will be satisfactory. If the ratio is different, extrapolation of data from one heater to another may be in error. The relation between friction factor, tube length, tube diameter, and number of velocity heads per return bend can be set out as follows:

Let n = number of velocity heads lost per return bend
D = tube diameter, ft.
L = tube length

L′ = total equivalent length of tubes plus return bends

The number of diameters corresponding to one velocity head is

$$A = \frac{1}{f}$$

If each return bend has n velocity heads loss, this corresponds in diameters to

$$B = nA = \frac{n}{f}$$

The equivalent length of one return bend is then

$$L_R = \frac{nD}{f} \qquad (38)$$

The total equivalent length of L ft. of tubes and n return bends is

$$L' = L + \frac{nD}{F} \qquad (39)$$

The total friction loss is proportional to

$$fL' = fL + nD.$$

Combinations of f and n that will result in the same over-all pressure drop may be found as follows. Suppose f is changed in the ratio k, what ratio c does this require changing n?

In the form of equations

$$fL' = fL + nD = \text{constant}$$

$$KfL + cn\,D = \text{constant}$$

so $$fL + nD = KfL + cn\,D$$

whence $$(K\text{-}1)fL = (1\text{-}c)\,nD$$

or $$c = 1 - \frac{(K\text{-}1)\,fL}{nD} \qquad (40)$$

TABLE 2

Enthalpy Values—Basis 1 Lb. Mixture

10.4 API Residuum—U.O.P. k 11.5

Percent Vapor	psia.	°F.	A.P.I. Gravity Dist.	A.P.I. Gravity Bottoms	Btu./Lb. Vapor	Btu./Lb. Bottoms	Total Btu./Lb. of Mix.
				10.4			
	1.0	580				277	277
	1.5	610				297	297
	2.0	635				316	316
0	3.0	675				345	345
	4.0	704				366	366
	5.0	725				384	384
	1.0	605	22.2	10.3	397x0.05= 19.8	293x.95=278	297.8
	1.5	635			415 " 20.8	316 " 300	320.8
	2.0	660			433 " 21.7	333 " 316	337.7
5	3.0	701			459 " 22.9	361 " 342.4	365.3
	4.0	730			473 " 23.6	385 " 365.5	389.3
	5.0	753			492 " 24.6	402 " 382.0	406.6
	1.0	625	22.0	10.3	410x0.10= 41.0	308x.90=277.2	318.2
	1.5	655			428 " 42.8	330 " 297.0	339.8
10	2.0	682			445 " 44.5	350 " 315.0	359.5
	3.0	722			472 " 47.2	380 " 342.0	389.2
	4.0	752			491 " 49.1	402 " 362.0	411.1
	5.0	773			503 " 50.3	419 " 376.5	426.8
	1.0	648	21.8	10.1	423x0.15= 63.5	326x.85=277.0	340.5
	1.5	677			442 " 66.3	347 " 294.6	360.9
	2.0	702			459 " 68.9	365 " 310.0	378.9
	3.0	742			483 " 72.5	395 " 335.0	407.5
	4.0	771			503 " 75.5	417 " 354.0	429.5
	5.0	792			518 " 77.6	433 " 368.0	445.6
	1.0	665	21.6	10.0	435x0.20= 87.0	338x.80=270.2	357.2
	1.5	696			453 " 90.6	362 " 290	380.6
	2.0	720			470 " 94.0	378 " 303.0	397.0
	3.0	760			497 " 99.4	408 " 327.0	426.4
	4.0	789			515 " 103.0	430 " 344.0	447.0
	5.0	809			519 " 105.8	446 " 357.0	462.8

For the particular case,

f was 0.02
n was 3.00
L was 27.
D was $\frac{4.5}{12} = 0.375$ ft.

If f is believed to be more correctly expressed as f = 0.025,

$$K = \frac{0.025}{0.020} = 1.25$$

so $$c = 1 - (1.25 - 1)\,\frac{0.02 \times 27}{3 \times 0.375} = 0.88$$

so $$cn = 3 \times 0.88 = 2.64 \qquad (41)$$

We will use f = 0.025 and 2.64 velocity heads per return bend in the following example:

Velocity pressure, from Equation (35)

$$p_{v2} = \frac{0.280 \times 10^{-4} \times 40.025^2}{6.225^4} \times V = 0.299\,V \qquad (42)$$

Also, from Equation (33)

$$\frac{dp^*}{dh} = \frac{-12{,}832 \times 10^{-8} \times 40{,}025^2 \times 0.025}{6.225^6 \times 10{,}640} V$$

$$= -0.03323\,V \qquad (43)$$

These have the following values for the various values of V

V	Velocity Pressure 0.299 V	dp*/dH 0.03323V
2.50	0.75 psi	0.0831 psi
2.00	0.60	0.06625
1.50	0.45	0.0497
1.00	0.30	0.0332
0.75	0.225	0.0248
0.50	0.15	0.01656
0.43	0.128	0.01425
0.25	0.075	0.0831
0.02	0.006	0.0007

In Figure 8 the integration is carried out on the basis of the return bend losses being considered as distributed; and neglecting the velocity pressure drop. Then from Equation (39) the correction factor required is

TABLE 3

Specific Volume 10.4° API Residuum and Vapor

Percent Vapor	p	T, °F	T, °R	0.00185 T/p Ft.³/Lb.	+ Liq. 0.019 Ft.³/Lb.	H Btu./Lb. Mixture
5	1	605	1,065	1.97	1.99	297.8
	2	660	1,120	1.036	1.055	337.7
	3	701	1,161	0.717	0.736	365.3
	4	730	1,190	0.550	0.569	389.3
	5	753	1,213	0.450	0.469	406.6
				0.00363 T/p		
10	1	625	1,085	3.94	3.96	318.2
	2	682	1,142	2.08	2.10	359.5
	3	722	1,182	1.43	1.45	389.2
	4	752	1,212	1.10	1.12	411.1
	5	773	1,233	0.895	0.913	426.8
				0.00537 T/p		
15	1	648	1,108	5.95	5.97	340.5
	2	702	1,162	3.12	3.14	378.9
	3	742	1,202	2.16	2.18	407.5
	4	771	1,231	1.657	1.674	429.5
	5	792	1,252	1.35	1.37	445.6
				0.00701 T/p		
20	1	665	1,125	7.90	7.92	357.2
	2	720	1,180	4.14	4.16	397.0
	3	760	1,220	2.86	2.88	426.4
	4	789	1,249	2.185	2.201	447.0
	5	809	1,269	1.778	2.794	462.8

$$\frac{L'}{L} = 1 + \frac{nD}{fL}$$

$$= 1 + \frac{2.64 \times 6.225}{0.025 \times 36 \times 12}$$

$$= 2.52.$$

The slope of the pressure drop curve at the outlet is

$$\frac{dp}{dH} = \frac{-12{,}832 \times 10^{-9} \times 40{,}025^2 \times 0.025 \times 2.52\ V}{6.225^4 \times 10{,}640}$$

$$= -0.0838\ V$$

At outlet, $\frac{dp}{dH} = -0.0838 \times 2.50 = -0.21$ psi per Btu.

The progress of the graphical integration is obvious on the figure, and the pressure p_i found at the intersection with the liquid line is 3.57 psia. If we add the velocity pressure at the outlet to this, we get

$$3.57 + 0.75 = 4.32 \text{ psia}$$

In Figure 9 the integration is carried out on the basis of the same outlet conditions, but with the return bend loss lumped, and also including provision for the velocity pressure distributed along the tube. For this case we have the following values:

V	p_u 0.299 V	dp*/dH 0.0332 V
2:50	0.75	0.0831
2.00	0.60	0.06625
1.50	0.45	0.0497
1.00	0.30	0.0332
0.75	0.225	0.0248
0.70	0.21	0.0232
0.50	0.15	0.01656
0.43	0.128	0.0143
0.25	0.075	0.00831
0.02	0.006	0.0007

For each line of constant V a short parallel section of line for V* is drawn above it, raised an amount corresponding to the velocity pressure $p_u = 0.299V$.

The velocity pressure p_{u2} at the outlet is 0.75 psi, so that $p^*_2 = 2.45 + 0.75 = 3.20$ psia. This is the starting point for the integration. The curve arrives at the value of 375.4 Btu/lb, which is one tube back from the outlet, at a value of $p^* = 3.53$ psia and a value of $V^* = 0.70$. At this point we must make a vertical jog corresponding to the pressure loss in the return bend at constant enthalpy. We have chosen as the pressure drop 2.64 velocity heads, but this is conventionally figured on the velocity head on the upstream side. We do not know what this is, because we have not yet found the pressure on the upstream side of the return bend, and so do not know the specific volume on which we base our estimate of the pressure drop. We have as our starting point the downstream end of the return bend. Call this point C. Thus

$$p^*_c = 3.53 \text{ psia}$$

$$V^*_c = 0.70$$

Call the point at the upstream side of the return bend D. Then

$$p^* = 3.53 + 2.64 \times 0.299 V^*_D$$

$$= 3.53 = 0.79^*_D \qquad (44)$$

This can be considered an equation of a straight line giving the relation of p^*_D and V^*_D. It is also necessary that the value of V^*_D at the pressure p^*_D be such that

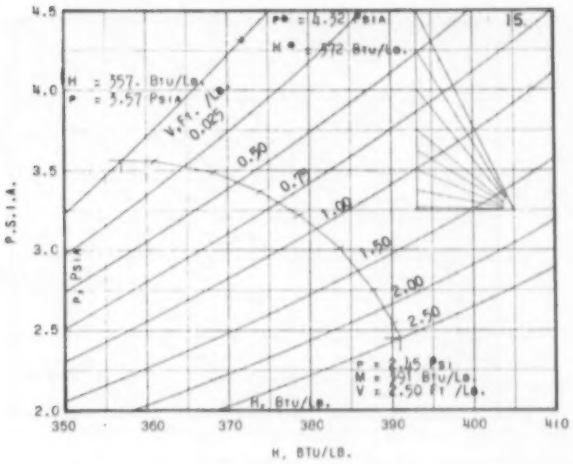

FIGURE 8—Pressure drop, exclusive of velocity pressure and with return bend loss distributed.

they conform to the physical relations that are embodied in the chart, since along the line H = 375.4 there is only one value of V* for each value of p*. (See Figures 8 and 9). We can pick off along the line of constant H = 375.4 Btu/lb the values of p* where the various lines of V* cross H = 375.4 with the following results:

V*	p*
0.70	3.53
0.50	3.74
0.25	4.05

In Figure 10 these points are plotted. A slightly curved line passes through them. The straight line of the Equation (44) is also plotted, and these two lines intersect at $p^* = 384.5$ psia and $V^* = 0.40$ ft³/lb. Corresponding to $V^* = 0.40$, one velocity pressure is

$$0.299 \times 0.40 = 0.1196 \text{ psi}$$

and 2.64 velocity pressures are

$$2.64 \times 0.1196 = 0.315 \text{ psi},$$

which is the pressure loss through the return bend. Adding this to 3.53

$$3.53 + 0.315 = 3.845$$

showing that the correct result has been obtained. The integration is then carried back from $p^* = 3.845$ psia, and the line of p* intersects the liquid line at

$$p_i = 3.87 \text{ psia.}$$

This is higher than the 3.57 psia obtained on Figure 8 for the case where the return bend loss was distributed, but velocity pressure neglected, but is lower than the 4.32 psia obtained by adding the outlet velocity pressure of 0.75 psi to the value of 3.57. This suggests that if the velocity pressure is omitted in determining the pressure drop, adding about one-half of the outlet velocity pressure to the pressure at the bubble point would be about right. If the conditions were such that evaporation started several tubes back, this would simplify matters and not result in much error.

It is now possible to plot the curve of static pressure p. Each point of the p curve will be directly below the point

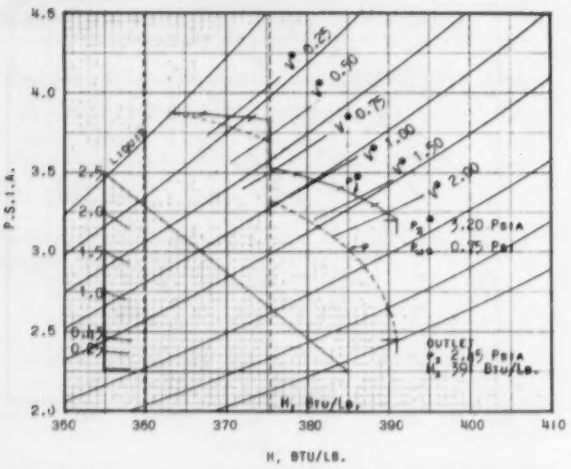

FIGURE 9—Pressure drop, inclusive of velocity pressure, with return bend pressure lumped.

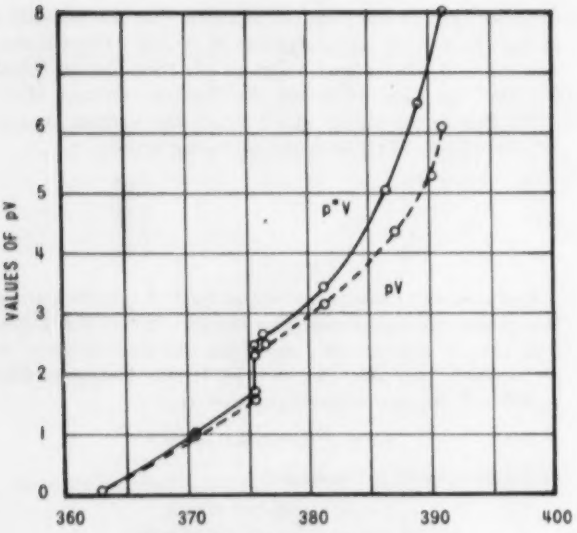

FIGURE 11—pV and p*V versus H.

on the p* curve an amount equal to the velocity pressure at that point. In other words at the intersection of the p* curve with a given value of V*, drop a vertical line to the corresponding line of V, and draw the p curve through the points thus located. This is shown on Figure 10 as a dotted line.

One other point is of interest. The purpose of operating under vacuum is to keep the maximum temperature below a given limit. It is possible that the temperature may be higher at some point back from the outlet that it is at the outlet. From the line of p and the values of H, and the fraction vaporized, as shown on Figure 7, the values of T can be interpolated. This has been done with the following results:

p	V	H	% Vapor	T
2.45	2.50	391	14.5	720
2.64	2.00	390	12.5	720
2.91	1.50	387	10	718
3.37	0.88	373.5	5	712
3.70		374.5	3.55	715

This demonstrates that for the conditions given, a temperature peak does not occur. This might not be the case for higher flow rates, where the expansion in the last tube might require more energy than is being added by heat through the tube walls. The extra energy would then come from the fluid, causing it to drop in temperature as the pressure dropped. (An extreme case, of course, is an expansion nozzle.)

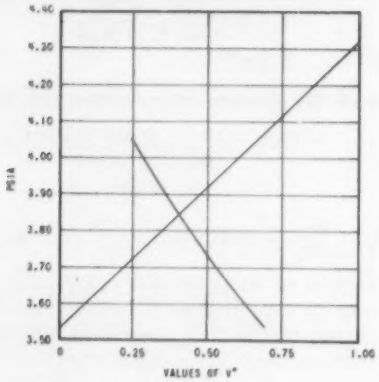

FIGURE 10—Pressure at inlet of return bend.

The value of p_1 at the bubble point as found on Figure 10, occurs at H = 363.5. The difference in enthalpy between the bubble point and the outlet is

$$391 - 363.5 = 27.5 \text{ Btu/lb.}$$

The gain in enthalpy per tube is 15.6 Btu/lb, so the bubble point lies 27.5/15.6, or 1.76 tube lengths back from the outlet. Except for the last two tubes, the tubes should therefore be designed on the basis of liquid flow, maintaining a high enough velocity to get good heat transfer and thereby avoid requiring excessive tube wall temperatures that might result in coking and hot spots.

From the values of p* and p where they cross the various lines of constant V on Fig. 9, values of p*V and pV vs. H can be computed. These values are plotted in Fig. 11. It will be noted that they are not at all linear, as contrasted with Figure 5. This shows why Ludwig's method will not work in this region of low pressure oil vapor.

This design method lends itself to ready study of alternative tube arrangements and flow rates. The principal work involved is in getting the chart of lines of constant V on the p vs. H grid, but this type information is required for any method.

ACKNOWLEDGMENT

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Hydrogen Fuel Makes Problems

Here are some of the reasons hydrogen makes trouble in furnaces.

Robert D. Reed,
John Zink Company, Tulsa

BURNING OF GAS fuel which contains free hydrogen has problems related principally to the mol percentages of free hydrogen to be found in the fuel.

There are two problems. One is the tendency for flash-back to occur in premix burners. The other lies in the relative flame volumes produced for any specific heat release with normal paraffinic and olefinic gases and with such gases in combination with free hydrogen.

The phenomenon of "flash-back" occurs in premix burners when two important conditions exist. The first condition requires that the gas-air mixture being produced by the burner is within the explosive limit range for the fuel gas being burned. The second condition requires that there be enough heat present to kindle the gas-air mixture as it flows from the mixing throat and immediately at the point of emergence.

There is considerable confusion regarding the meaning of "explosive limits" and "limits of inflammability." These terms mean the same thing (A.G.A.) in practice. The explosive limits for hydrocarbons are relatively narrow. The explosive limit increases as the molecular weight of the fuel increases in the paraffins. Olefins and particularly ethylene have wider explosive limits than most paraffins.

Explosive limits for hydrogen are almost twice as great as for ethylene and are more than six times as great as for methane (A.G.A.). Thus it is clear that if significant mol percentages of hydrogen are present in the fuel the tendency for flash-back is tremendously increased.

There has been considerable opinion that the rate of flame propagation for the fuel involved determines the flash-back characteristics. Closely controlled experiments and field experience do not confirm the opinion. At normal condition of operation the velocity of discharge for the air-gas mixture is far in excess of the rate of flame propagation for the fuel.

The rate of flame propagation for methane is a little greater than 2 feet per second; for ethane the rate is substantially 3 feet per second; for ethylene the rate is approximately 5 feet per second and for hydrogen the rate is 16 feet per second (Haslam & Russell). The rate for hydrogen is representative of discharge from a pressure of 0.057 inches of water which is far lower than the 2 inches of water or greater pressure to be found in all premix gas burner design for discharge of gas-air mixture. The velocity due to discharge from pressure of 2.0 inches of water is in the order of 94.4 feet per second which is nearly six times as great as the rate of flame propagation for hydrogen.

In determining the cause of flash-back, Haslem & Russell give a clue in the discussion of tube diameter as it governs the rate of flame propagation. It is reported that Payman and Wheeler who were working with a mixture of coal gas and air could not propagate a flame through a tube 2mm in diameter. In this case there was no movement of the air-gas mixture and the H_2 content of the coal gas was in the order of 50 percent. Such a gas which contains both ethylene and free hydrogen is particularly vicious in its tendency to flash-back yet in the small tube with no movement of the gas-air mixture it was impossible to get flame to move through the tube.

Failure of the flame to move through the small tube is an expression of the Humphrey Davey principle of the Miner's Lamp in which a screen dissipates heat so rapidly that a temperature level required for kindling of the gas-air mixture cannot pass through the screen. The small tube acts like one of the screen apertures but its effect is even greater than that of the screen because of its length and its greater ability to absorb heat.

A further point in the determina-

Meet the Author

ROBERT REED, chief engineer for John Zink Company in Tulsa, has been associated with the process industries since 1921. He joined the Zink company in 1936, and during the past ten years has conducted lectures on process heating at the University of Tulsa, Texas A&M College and other engineering schools. Reed, author of a number of technical articles, is registered as a professional engineer in Oklahoma; listed in *Who's Who in the South and Southwest* and *Who's Who in Commerce and Industry*, and was a student at Oklahoma A&M College.

tion of the flash-back characteristics of a burner lies in the nature of the orifice or orifices through which the gas-air mixture emerges for burning in the combustion zone. Minimum tendency for flash-back is found if a perfectly smooth orifice having parabolic approach contours is used. The tendency for flash-back increases with departure from the characteristic of the perfect orifice.

It is believed that the increased tendency for flash-back with imperfect orifices which are typical of discharge ports for gas-air mixture in premix burners as now manufactured is due to creep-back of flame between the wall of the orifice and the stream of gas-air mixture flowing through the orifice. Trinks is in agreement with this opinion. The nature of the fuel would determine the rate of creep-back as also would the requirement that the gas-air mixture be within the explosive limits for the gas.

The creek-back of flame within the confines of the orifice permits the existence of a heat level which is capable of igniting the gas-air mixture as it flows up to the discharge orifice and flash-back occurs. It is again presumed that the gas-air mixture is within explosive limits.

In any given burner it is possible to avoid flash-back if the volume of premixed air is less than that which will cause the gas-air mixture to be within explosive limits. The delicacy of adjustment for the volume of premixed air is in direct ratio to the wideness of the explosive limit characteristics for the fuel. This is to say that with hydrocarbons which have relatively narrow explosive limits the adjustment is not at all critical. With hydrogen which has very wide explosive limits the adjustment of primary air volume is extremely delicate if flash-back is to be avoided.

The requirement for extreme limitation of primary air to avoid flash-back has compelled some burner manufacturers to revise their burner capacities down-ward when fuels containing large percentages of free hydrogen are to be burned in premix operation. The ratio of primary air to secondary air goes downward and unless special provision is made for improved mixture with secondary air in the combustion zone the performance of the burner is below standard.

The problem of flash-back can be completely eliminated through the use of so-called "raw gas" or nonpremix burners. Since no air is mixed with the gas before it emerges for burning such burners cannot flash-back unless appreciable quantities of oxygen are present in the gas as it is delivered for burning.

It has been shown that the design of the burner block does not have any significant effect in design for the burning of high hydrogen gases. It has been shown that the primary air factor for gases rich in free hydrogen must be greater than is normal for hydrocarbons in the absence of free hydrogen. The latter requirement has necessitated close study of injector design in all its aspects. The study has produced some important deviations from standard venturi design but at this time the details cannot be supplied.

It has been shown that the presence of free hydrogen in the fuel gas can either accelerate or retard the burning of the gas. It is difficult to understand why the addition of a component which in itself is capable of extremely rapid burning could interfere with combustion. It is the opinion of many authorities that the very rapid burning characteristic of free hydrogen is the actual cause of the retarding action.

With mol percentages of free hydrogen in the range between 10 and 50 percent in hydrocarbons, the flame volume is from 125 to 200 percent of the flame volume produced by a typical hydrocarbon fuel. There is a marked tendency for the burners to produce hazy flames.

At some point which is very hard to determine and which is between 50 percent free hydrogen and 60 percent free hydrogen, the effect of acceleration of burning due to the hydrogen begins to become evident. Flames at 60 percent free hydrogen have less volume for a specific release of heat than is the case with 50 percent free hydrogen. It is at this point that we find the effect of acceleration more than compensating for the effect of retarding combustion.

Authorities disagree as to why hydrogen in the range as discussed interferes with combustion. One group asserts that the hydrogen preempts the oxygen supply in the turbulent zone immediately after discharge from the burner to force the intermediate hydroxylation products formed in normal burning of hydrocarbons to burn in a less turbulent zone or by diffusion.

Another group insists with equal fervor that the presence of the free hydrogen interferes with the normal hydroxylation process to form additional intermediate compounds which delay combustion because of the heat of reaction taken from the flame and because a new series of reactions must exist prior to the production of CO_2 and H_2O. It is to be conceded, in the absence of firm data in negation of either explanation, that there is reason to believe either or both may be correct.

From the discussion it is seen that the best means for correction of greater than normal flame volume for a specific heat release is the provision of a very high primary air factor. Large volumes of air, premixed with the gas before discharge for burning make oxygen immediately available for the combustion reactions. The immediate availability of oxygen relieves necessity for mixture with secondary air in the combustion zone and accordingly permits very rapid burning of the gas. Experience has shown that the high primary air factor is relatively more important with high hydrogen gas than it is with hydrocarbons.

Burners which normally operate with relatively low primary air factors when hydrocarbons are the fuel do not perform satisfactorily when the mol percentage of free hydrogen begins to become significant.

It may be summarized as follows:

1. Gases containing high mol percentages of free hydrogen can be burned satisfactorily.
2. Special care is necessary in the design of the venturi which is to inspirate and mix air with the gas.
3. Tile or refractory design is relatively unimportant.
4. The entire burner must be specifically designed for the high hydrogen gas.
5. The presence of greater than normal flame volume for a heat release should be anticipated in the design of the furnace. ##

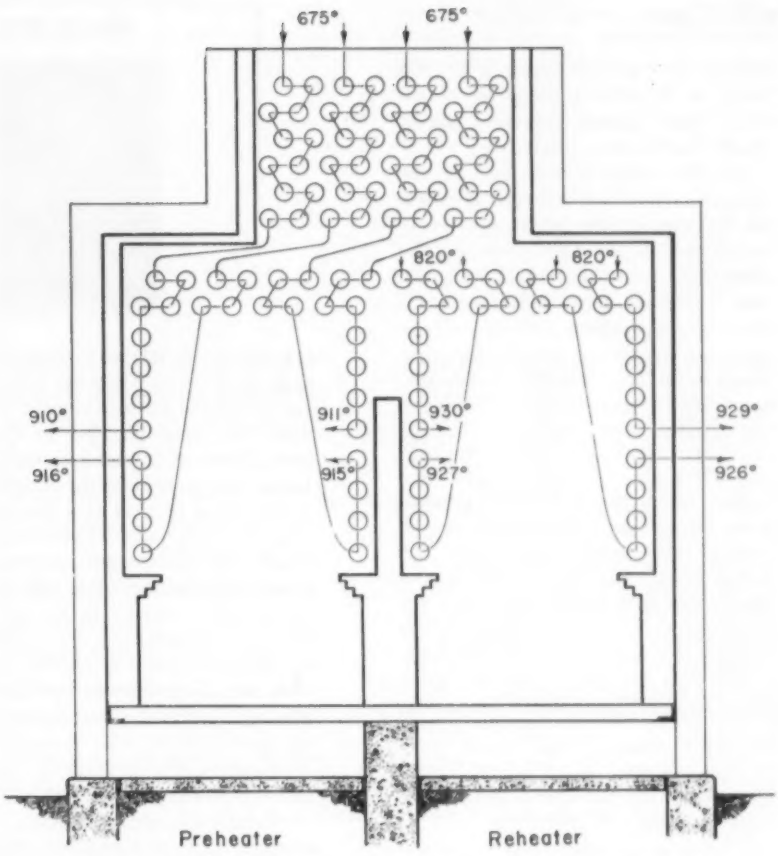

FIGURE 1—Diagram of combined preheat and reheat furnace with multipass coils.

FIGURE 2—Three heaters in a small reforming unit.

It pays to . . .

Select Cat Reformer Heaters with Care

Here are the principles to apply in selection of reforming heaters for long, low-cost service.

George E. Rose and Harold J. Born,
Born Engineering Company, Tulsa

THE UNIQUE PROBLEMS in catalytic reformer heaters must have careful consideration if you are to get maximum economy and avoid unnecessary shutdowns.

The initial cost of fired heaters represents a big part of the total cost of a Reforming unit. Yet, improperly selected, these heaters can be the source of much unnecessary operating and maintenance expense. Also they may limit the capacity of the unit.

In reforming, fired heaters are used to preheat the unreformed naphtha and recycle hydrogen prior to entry to the first reactor, and for reheating of the naphtha and recycle prior to entry to subsequent reactors. Also, if a pretreater or desulfurizer unit is required, an additional fired heater is used for preheating the charge to this unit.

Many of the same principles of good equipment selection applying to other refinery heaters also apply to reforming heaters, but for maximum economy special consideration should be given to the following:

1. **Tube Material:** Operating temperatures in the 950° F range plus the presence of large quantities of hydrogen, coupled in many cases with sulfur and other corrosion problems, demand careful consideration of tube material.

2. **Multipass Coils:** Minimum pressure drops require multipass coils with uniform flow and heat distribution.

3. **Furnace Efficiencies:** Although an old problem, the high inlet temperatures of the reheater streams make new solutions necessary.

4. **Proper Selection of Burners:** The use of low calorific, high hydrogen fuels necessitates special consideration.

5. **Overload Capacity:** Variation in

Select Cat Reformer Heaters with Care . . .

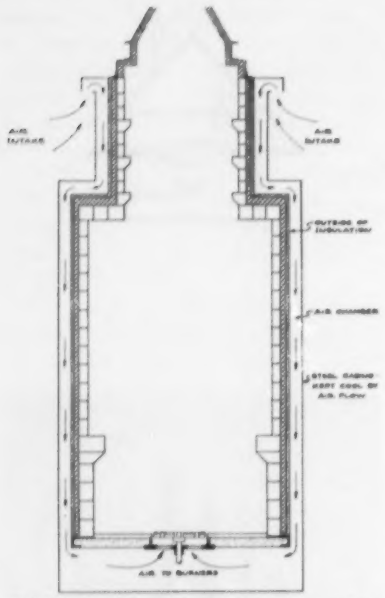

FIGURE 3—Furnace arrangement for preheat of secondary air through heat recovery.

recycle gas ratio may cause severe overloading of heater.

Tube Selection—Tube material in early reforming heaters was of 4-6 percent chrome, ½ percent moly alloy but was soon superseded in most cases by 2¼ percent chrome, 1 percent moly, or 1¼ percent chrome, ½ percent moly. Though lower in first cost, these latter alloys possess higher creep strength resistance and better stress-rupture properties which make their application to reforming service fulfill the requirement of maximum economy.

In some recent installations the pretreater, or desulfurizer heater, is being specified in 4-6 chrome or higher chrome alloys, particularly where sulfur corrosion is expected.

Additionally, very recently, the tubes in some pretreater heaters are being either calorized or aluminized on the inside.

Once the selection of the particular alloy for the tubing has been made then the refiner is faced with the problem of specifying the proper tube wall thickness.

There are several methods for setting forth the minimum wall thickness requirements and we will mention only two herein. One common way to specify tube wall thickness is as follows. The minimum wall thickness of the tube shall be based on either rupture stress plus ⅛-inch corrosion allowance or 1 percent creep in 100,000 hours or 1 percent creep in 10,000 hours plus ⅛-inch corrosion allowance, whichever is greater.

Another method is to specify the allowable stresses and a typical example for two of the alloys previously mentioned is set forth below. The allowable stresses for calculating the tube wall thicknesses shall not exceed the following values:

Maximum Metal Temperature °F.	1¼% Cr. ½% Mo.	2¼% Cr. 1% Mo.
1000	13,700	13,700
1050	10,000	10,200
1100	7,000	7,700
1150	4,200	5,500
1200	2,800	3,700

Both of the above methods presuppose the proper calculations of the outside tube metal temperature. The outide metal temperature is the sum of the inside fluid temperature plus the temperature across the film plus the temperature across the wall of the tube.

The film coefficient may be evaluated from the Dittus-Boelter equation:

$$h = .0225 \frac{k}{d} \frac{(dV)^{.8}}{(z)} \frac{(cz)^{.4}}{(k)}$$

h = BTU/hr. — sq. ft. — °F.
k = BTU/hr. — ft. — °F.
d = inside pipe diameter
V = #/hr. — sq. ft.
z = #/ft. — hr.
c = BTU/# — °F.

The thermal conductivity can be determined from tables for the various hydrocarbons and hydrogen which makes up the charge material. The viscosity can be figured from the molecular relationship. The specific heat can be evaluated from the poundage relationship.

Once the film coefficient has been determined the temperature through the film can be calculated by dividing the maximum inside transfer rate by the film coefficient. To this temperature must be added the temperature rise through the metal wall which can be calculated by dividing the maximum rate through the wall by the transfer coefficient of the metal times the wall thickness of the tube. The sum of these two figures added to the inside fluid temperature will result in the expected metal outside temperature.

Having properly determined the above, the actual minimum tube wall requirement can be determined by using any one of the following generally accepted formulas: Barlow, Lame or the ASA Piping Code.

Multipass Coil Consideration—In the normal catalytic reforming process, recycle gas, primarily hydrogen, is mixed with raw naphtha before charging to the preheater. This recycle gas must, therefore, be compressed up to the pressure existing at the preheater inlet. Since each additional pound of pressure drop through the heaters adds one pound to the required compressor discharge pressure, pressure drops must be maintained at the lowest practicable minimum.

Low pressure drop requirements of the required magnitudes led inevitably to multipass coils. Flow controls for each individual pass were not only prohibitive in first cost, but would tend to work against the goal of minimum pressure drop. Thus, if the outlet temperatures from each pass are to be comparable, the heat input to each pass should be distributed uniformly. Also, since distribution of the naphtha within the various passes is controlled completely by internal pressure drop, the equivalent footage through each pass must likewise be nearly equal.

Figure 1 illustrates a multipass heater design which accomplishes the required uniformity of outlet temperature. There are no flow controls on

Meet the

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this heater, and actual operating temperatures are shown superimposed on each coil. Note that they are practically identical within the accuracy limitations of the thermocouple.

One of the prime considerations in assuring uniform flow characteristics as well as heat distribution in multipass coils is the method of achieving the pass arrangement.

One method is to use multipass manifolds connecting the various tubes together. This method has the obvious disadvantage of permitting channeling and an uneven flow through the tube depending upon design of the manifold and the location of the inlets and outlets as well as the tube locations. This type of multipassing has led to overheating and early tube failures in many cases.

Another method has been to use a number of individual coils connecting tubes through the use of two-hole U-bends or headers. This way of multipassing has the obvious advantage of a once through pass with no opportunities for channeling or poor distribution from the inlet to the outlet. This latter method has gained wide acceptance in reforming service.

Furnace Efficiency—Because of the relatively high oil temperatures, the efficiency of many reformer heaters has been very low, resulting in excessive fuel costs. This is particularly true in the case of the interheaters or reheaters, which reheat the naphtha up to reaction temperature.

The naphtha temperatures into the reheaters are usually in the order of 840 F. to 925 F., and these high inlet temperatures make conventional convection sections impractical. As a result, all-radiant heaters have sometimes been utilized for these services, with thermal efficiencies in the range of 55-65 percent, or even lower. These low efficiency heaters not only waste fuel, but the resultant high stack temperatures lead to excessive maintenance of stacks and breechings.

Several possible solutions to this problem are available. Figure 2 is a photograph of a unit where each of the reformer services is in a separate heater, with a steam generating convection used as an economizer in each heater. Here the over-all efficiency of each heater was raised to 80 percent NHV.

The use of separate heaters for each service, of course, provides the maximum in individual controllability. Also, it is possible in many cases to preassemble and skid mount the individual heaters and so minimize field labor expense.

Where there is no steam generation or superheating requirement, efficiencies of the reheaters can be improved by combining them in a single setting with the preheater as shown in Figure 1. In this arrangement one or more reheat sections are designed as all-radiant cells with the flue gases from each cell passing through a convection section which consists of the inlet side of the preheater coil. The efficiency of the multicell heater without steam generation is normally in the range of 70-78 percent based on the net heating value of the fuel and this efficiency, of course, can be further improved by the use of a design feature such as is shown in Figure 3. Here the heat which normally would escape to the atmosphere by radiation is reintroduced into the furnace as preheated secondary air. An increase of 2-4 percent in the over-all efficiency can be expected by the addition of this feature.

Multicell heaters have been designed with practically every conceivable combination of coils. In general, it is considered good practice to combine coils whenever the economics (usually over-all efficiency) point in that direction. However, whenever it is likely that one heater may be required to be in operation while the balance of the unit is off-stream, it is desirable to isolate this unit in a separate setting. This is usually true in the case of the pretreater or desulfurizer heater.

Separate temperature control of the individual services in a multicell heater can be a severe problem, unless the heater design provides this controlability. The combined heater illustrated in Figure 1 provides separate control of each service. Here, by use of separating bridgewalls, the same degree of individual control can be maintained as with completely separate heaters.

It should also be noted that the bridgewalls are shielded by tubes and are thus protected from high temperatures. Because of this shielding, they will not bring on the maintenance problems that unprotected bridgewalls often do.

Selection of Burner—As has been pointed out, it is possible by careful design to maintain uniformity of outlet temperatures from non-flow controlled multipass coils.

However, regardless of design, it is readily apparent that shifting burner flame patterns and undependable flue gas distribution will alter the heat input to the various coils and cause outlet temperature differentials. Therefore, it is also necessary to completely shield the burners against wind interference with flame pattern.

The normal reforming operation produces as a by-product a high hydrogen content, low calorific make gas, the LHV being 400-600 BTU per cubic foot. In many operations, it is desirable to use this gas as fuel for the reformer heaters without blending with other higher calorific value refinery gases.

This is readily possible, provided the necessary design precautions are taken.

The first problem that arises is that due to the high hydrogen content, the rate of propagation of the flame is high, and precautions must be taken to prevent flashback of the burner. This has been accomplished in the aspirating type of burner by the use of a more efficient primary air aspirator, together with smaller burner

ports through which the comingled gas and primary air issue into the heater.

The smaller burner ports provide the necessary higher velocities, while the more efficient primary air aspirator maintains the higher pressure within the burner which is necessary to maintain the higher velocities. By this means, the reformer make gas has been successfully burned, and burner turn down ratios maintained at acceptable levels.

The lack of flame luminosity when burning high hydrogen content gas presents another problem. Radiant heat transfer rates depend to some degree on this luminosity, and unless compensated for in the design of the heater, this lack of luminosity can cause either localized overheating or outright failure of the heater to perform at rated capacities. Naturally, this condition is aggravated in any heater which presents all "black" surface to the burners. In other words, one in which all surfaces (such as refractory walls) which could act as reradiating surfaces are shielded by tubes. By way of contrast, the heater design shown in Figure 3 provides a "built-in" solution to this problem.

Originally, this heater design included a so-called "free combustion zone" which basically was intended to provide an area of free combustion for the burner gases and to positively insure against flame impingement on tubes. However, with the advent of high hydrogen fuel gases, this same zone provides the reradiating surfaces necesary for good radiant heat transmission. In actual operation the burner gases sweep the floor and untubed lower sidewalls, lighting them to an incandescence which adequately replaces the luminosity lacking in the flame itself.

Also, the close spacing of the relatively large number of burners along the floor lends uniformity to this incandescence and assures even heat inputs along the length of the tubes.

Overload Capacity—Experience has shown that a very large variation in heat requirements may exist during the operation of a catalytic reforming unit. This is due to several factors, including: the desired degree of octane improvement, the activity of the catalyst in the reactors, and particularly the ratio of recycle hydrogen to raw naptha being processed. Hydrogen has a specific heat of approximately five times that of naphtha vapor, so it is apparent that a relatively small increase in the amount of hydrogen being recycled can greatly increase the total heat load on the reformer heaters.

For example, the design conditions on a typical reformer preheater were as follows:

Charge to the unit: 100,000 #/hr. naptha vapor including 8 wt. % H_2
Inlet Temperature: 725 F
Outlet Temperature: 925 F
Calculated heat load (Design)

Naphtha	— 100,000 # x .92 x .735 x (925-725) =	13,520,000 BTU/hr.
Hydrogen	— 100,000 # x .08 x 3.52 x (925-725) =	5,650,000
Design Heat Load		19,170,000 BTU/hr.

However, some months after the unit was in operation, the amount of hydrogen recycle was increased from 8 wt. % to 22 wt. % to give optimum octane improvement. Total charge to the unit remained the same (100,000 #/hr.)

Calculated heat load (Operating)

Naphtha	— 100,000 # x .78 x .735 x (925-725) =	11,470,000 BTU/hr.
Hydrogen	— 100,000 # x .22 x 3.52 x (925-725) =	15,500,000
Operating Heat Load		26,970,000 BTU/hr.

The preheater was operating at 140 per cent of design.

It should be noted that this overload was caused by a change in the hydrogen recycle ratio *only,* while total charge to the unit remained constant.

Because of the definite possibility of future heater overloads, it is recommended that average heat transfer rates in reformer heaters be kept at a relatively moderate rate, on a design basis. In the case described above, the average radiant rate on a design basis was 10,000 BTU/sq.ft./hr., but under the overload condition was nearly 15,000 BTU/sq. ft./hr.

Another factor that becomes extremely important in view of the overload possibility, is that of burner sizing and burner location with respect to tube surfaces.

Not only must the burners be amply sized in order to provide the releases necessary at the overload condition, but definite provision should be made to avoid flame impingement on tubes when the larger releases are required.

One method of accomplishing this is shown in Figure 3. Here the tubes are placed up and away from the burners, with an untubed area, or "free combustion zone" surrounding the burners. It will be readily seen that since there are no tubes adjacent to the burners, very large heat releases can be obtained with no possibility of flame impingement on tubes. As a further precaution against either extreme overfiring or misoperation of the burners, a firebrick corbel section (a type of baffle) provides a physical barrier between burners and tubes.

In the foregoing, specific mention has been made of only those heater selection considerations specifically applying to catalytic reforming service. Naturally, in addition to these, the same consideration of mechanical specifications should be given as for heaters for any other refinery service.

Mechanical failures frequently occur in the refractory enclosures. The use of sectionally supported refractory panel type construction has provided not only a wall which is maintenance free but also one which can be easily inspected. Another mechanical specification which is contributory to long tube life is that which deals with a type of casting which supports the tubes or coils in the heater. Good practice indicates that in the high temperature zone these castings should be specified as 25 per cent chrome 12 per cent nickel alloy steel castings, conforming to ASTM B-190 Type I or II. To insure against tube sagging it is also necessary that these castings be closely spaced and be designed to insure adequate tube support together with provisions to withstand expansion and contraction of the tube. Another very important consideration is the removability of the castings or the tube without removing other tubes.

Before leaving the subject of mechanical specifications the matter of the heater structure itself should be discussed. All tube supports should, of course, be suspended from the steel structure with no bearing on any refractory walls. The steel structure should be designed to American Institute of Steel Construction specifications and where there are special requirements for high wind loadings or if the heater is to be erected in earthquake areas these conditions should be specified. # #

How to Get Basic Heater Specs

Here are the ABC's of developing complete direct fired heater specifications.

Fired Heater Symposium

Lowell C. Cockel, Jr.,
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THERE CAN be a large number of variables involved in the design of a direct fired heater. To arrive at the most desirable solution to a given problem, detailed information must be established concerning each one operating in the particular application. Such anticipation may be difficult, in some cases approximate, nevertheless essential to an economical, dependable design. Here is an outline of the basic items involved in such specification and a description of design and performance data needed in early consideration of a particular application.

Perhaps first, it is important to specify carefully the elementary data about the fluid to be heated. If the fluid is a simple one, such as water, specification may be an easy matter. Even so, it may be important to know considerably more than just "water" if the water contains impurities. Whatever the fluid, enough must be said to fix: (1) the composition of the fluid at each point in the heater, (2) the pertinent properties of each phase of the fluid at each point in the heater, that is, specific weight, viscosity, thermal conductivity and specific heat, (3) the conditions under which undesirable states occur, such as thermal decomposition, rejection of insoluble salts, increasing corrosiveness, etc.

It is often impossible to fix the fluid with great precision. Perhaps the fluid may be expected to vary somewhat during the life of the heater. Fortunately it is sometimes possible to accommodate a rather wide range of fluid data without important penalty. However, the range of anticipated values should be specified, as should the sets of values expected to occur together.

After the fluid is specified, it is necessary to specify how much the fluid is to be heated. That is, how much sensible heat, latent heat and heat of reaction must be added to bring the fluid to the desired condition. The designer may be able to find these data given the terminal temperatures, the inlet pressure and the allowable pressure drop. However, laboratory determinations or other data not commonly available may be necessary and should be provided.

Sometimes it is important to specify how the heat is to be added. This point may arise in cases where reactions occur in the heating circuit. In such cases a detailed specification of the desired manner of heating including rate of heating limits, temperature limits and variations of these from point to point should be supplied.

Then, when the total flow is specified, the data mentioned thus far should form a consistent set with the total duty, which in turn should balance with the heat losses from the associated equipment.

The fuel can be specified now so that the heating value, carbon-hydrogen ratio, specific weight and impurities to be expected are established. The temperature and pressure at which the fuel is available should be specified as should viscosity data at several temperatures for liquid fuels. Availability of steam or low pressure air may be important, in which cases pressure, temperature and degree of saturation (for steam) should be mentioned. Yet again the range of anticipated values can be important.

It is necessary to fix the efficiency to be provided. If that is to be an economically sound decision it is well to consider first some performance

features of direct fired heaters as they affect the decision.

One class of heaters is radiant heaters, so called because heat transfer is principally by radiation from the products of combustion, whence draft requirements can be modest. Such heaters may be about 50 to 60 percent efficient depending on the conditions to be met. The size of such heaters for a given duty may change rapidly with efficiency. Their proportions and size for a given duty depend upon the allowable maximum rate of heat transfer to the fluid. The latter depends upon the fluid and the allowable pressure drop.

Either the efficiency or the average heat transfer rate may be increased by baffling of the products of combustion to increase convective heat transfer in some parts of the heater. Then the heater can be termed a radiant-convection heater. Feasible efficiencies of such heaters as high as 70 to 80 percent may be encountered depending on the conditions to be met.

The mentioned classifications are rough, however they illustrate that the first cost per unit heat transfer increases with efficiency, but not continuously or uniformly. There remain additional factors influencing efficiency decisions, which follow in connection with related items.

The fluid being heated can be regarded as a coolant, which removes heat from the tubes so that their temperature is allowable. The bulk temperature of the fluid at any point

in a heater is by no means the maximum fluid temperature at that point. Differences between these two quantities of several hundred degrees may be encountered. The difference depends on the fluid and the pressure drop. Consequently the cost of pumping the fluid can be important in deciding the efficiency, size and proportions of the heater.

Average heat transfer rate is not sufficient to indicate what the extreme conditions of tube and fluid temperature will be. It may be that the maximum heat transfer rate and its location in the heater will be critical. The latter is related to the geometry of the heater and the manner of flow of the fuels and products of combustion, thus a factor in the cost of providing a given efficiency. Even though a very low average rate prevails, the maximum rate may be far more. On the other hand it is possible to arrange a very high average rate exceeded only slightly by the maximum. The most economical heater may produce the greatest non-uniformity of heat transfer. The decision on the degree of uniformity or non-uniformity of heat transfer which is desirable is probably most often related to the ease with which the fluid to be heated acts as a coolant. For example, it is easy—that is, not costly of power—to remove relatively large heat flows through thin tubes with water, so non-uniformity of heating might be of little importance. Not so when heating asphalt, for it is difficult to make low temperature asphalt absorb large heat flows without overheating the fluid boundaries, thus a desirable heater may be the one with greatest uniformity of heating. If reactions occur within the tubes, uniformity or other specific distribution of heating may be important.

The corrosion allowance in tubes, the design pressure, allowable stress and allowable creep dictate the tubewall thickness. There are occasions when the tubewall resistance is an important part of the total resistance to heat transfer. Further, the tubewall temperature may be limited by the material. Thus it is important to give sufficient data to permit the most economical choice of material, since the choice can be intimately associated with the size and proportions of the heater and thus with the cost of providing a given efficiency.

The manner in which the heater will be used can be important. Thus, heaters to be used only infrequently should hardly be of high efficiency. As mentioned previously, the range of operation can be important. Since the distribution of heat transfer may change with heat load, the range of operation may strongly influence the proportions of the heater, as may the magnitude and rapidity of load fluctuations.

The excess air to be used in combustion must be established and need be very little for desirable combustion conditions. Changes in excess air can result in important changes in efficiency, capacity and distribution of heating. Increases may reduce the efficiency rapidly and increase draft losses. It can be expected that the most economical heater will usually occur when very little excess air is used.

Instrumentation and controls can be provided when the degree of supervision available and the necessity for control are fixed. The process data may partly fix the instrumentation requirements, however, the choice may also be largely related to desires for economy, convenience, safety and response to varying conditions.

Accessories to be provided should be specified. These may include eyeports, access doors, ladders, platforms, guards, railings, covers and other items related to ease and safety of maintenance and inspection. The nature of the duty, amount, kind, location and cost of maintenance may be important factors. One important maintenance deserving of special consideration may be the manner and frequency of cleaning of tubes.

The location of related process equipment and connections to it, the amount of space available for installation and the minimum stack height above both grade and platforms should be mentioned. Also it may be important to specify points at which personnel or equipment will be near heater parts and what temperatures can be allowed.

Any data related to the heater structure should be fixed. Maximum wind and seismic loads should be included, as should data regarding soil and foundation bearing limits. Sometimes it is advantageous to have a portable unit, whence any factors pertinent to this should be mentioned. If shipment or erection will involve unusual restrictions, such as weight or size limits, these limits should be established.

The design of a heater can only be most economical when executed with complete, accurate cost information. From the previous remarks, the designer must then have the following data regarding costs determined by the particular application: (1) cost of fixed charges, (2) plans for depreciation, and (3) cost and availability of fuel, steam, compressed air and power. These data can only be used properly if the other items mentioned above are each well established. ##

Meet the Author

LOWELL C. COCKEL, JR., with Sandberg-Serrell Corporation, a California firm of consulting engineers, is concerned with the rapid heating of heavy structures at high temperatures. A mechanical engineering graduate from California Institute of Technology, where he also received a master's degree, Cockel was connected with Shell Oil Company and Industrial Engineers, Inc., before joining the Sandberg-Serrell organization. With Shell, his duties involved the inspection, testing and adjusting of direct fire heaters. When he joined Industrial Engineers he was concerned with designing and developing direct fired heaters and other heat and mass exchange equipment for both steady and transient operation. He is registered as a professional engineer in California.

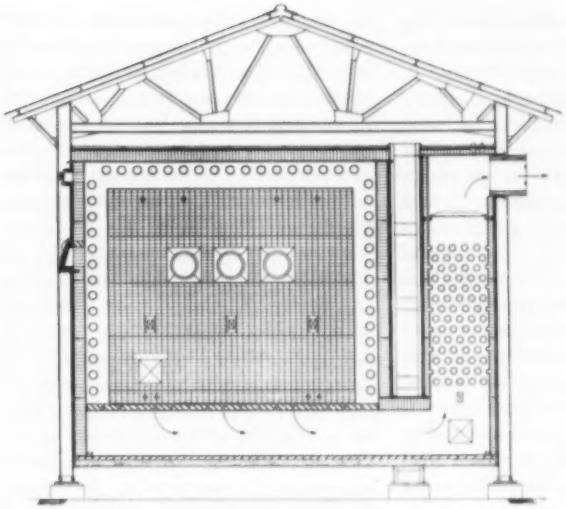

FIGURE 1—Fired tubular heater arranged for firing very heavy residual fuel.

Here is an up-to-date review of what is being done and what problems must be recognized in firing very heavy fuel in furnaces.

How to Use Resid as Furnace Fuel

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FIRING HEAVY residual fuel can provide economic advantages and solve disposal problems.

Refiners reserve for sale higher grade petroleum products—gas, liquid or solid and aim to fire their heating equipment on as low a grade of fuel as is possible within the bounds of plant economics and current technology. The trend of increasing cost of fuel gas lends emphasis to use of liquid fuel. The lowest grade and usually the cheapest fuel oil available in any refinery is the residue of the crude after the more worthwhile and saleable portions have been removed. Crude residue, or residual fuel, has essentially the same combustion heating value, pound for pound, as the lighter more costly grades of liquid fuel. Firing refinery furnaces on low cost residual fuels is, therefore, a wise practice from a fuel economy viewpoint. Disposing of this unwanted refinery by-product in this most economical manner is also good plant housekeeping.

Combustion and heat transfer equipment designed for firing residual fuels is, unfortunately, relatively complex and usually more costly than that required for the lighter grades of fuel. Operation of such equipment is more exacting, maintenance more time consuming. The cost of firing refinery equipment on residual fuel, and the potential return in form of fuel savings, both appear to increase as the grade of fuel fired becomes heavier. The refiner is able to develop almost any grade of the fuel that he may desire by blending back the residuals with lighter petroleum cuts. By blending back his residuals, in this manner, the refiner increases the unit cost of his fuel. At the same time, however, he also eases his potential operating and long range heater maintenance costs. It becomes a matter of economic study for the designer or refinery engineer to determine that grade of residual fuel which will provide the most favorable balance between fuel saving and added cost of equipment and maintenance.

TABLE 1
Typical Residual Fuels
Properties and Analysis

	Bunker "C" No. 6 Fuel Oil	Pitch Kuwait
Carbon, percent weight	84.2	83.9
Hydrogen, percent weight	13.0	10.4
Sulfur, percent weight	2.8	5.4
Nitrogen, percent weight		.3
Viscosity cs @ 122 F	400	
212	32	3,250
300	7.8	
360	4.3	
500		8
Colorific Value, Btu./lb. (gross)	18,280	17,500
(Net)	17,300	16,600
Ash Content, percent weight	0.08	0.06
Vanadium Content, percent weight (V_2O_5)	0.04	0.02
Gravity, °API	11.0	5.0

Economics and technical limitations are not the only factors which determine the most favorable grade of residual fuel for any one refinery. Geography, company and national policy and local conservation laws also have substantial influence. It is not unusual, therefore, for the term "residual fuel" to mean something different in each refinery. In those refinery areas where unlimited quantities of natural gas are available, at low cost, residual fuel may mean nothing more formidable than 10°-12° API Bunker "C." Certain European refiners apply the same term to the 300 F. melting point asphalt that they use as refinery fuel. Table 1 lists some of the physical properties and impurities that characterize typical residual fuels. For purpose of discussion, residuals will be considered as those liquid fuels heavier than 5° API or those having a melting point above 100 F.

Basically, if refinery equipment is fired on cheaper grades of fuel, obvious fuel cost savings result. The amount of such savings will depend on the relative costs of fuel as established by local conditions and refinery policy. A review of equipment, maintenance and operating factors which technically tend to limit the broader

use of the heavier residuals is now in order.

Fuel Handling—The residues from various refinery processes are usually collected and mixed in a common settling tank where they are blended into what is ultimately called fuel. These residues contain a concentration of all the solid and chemical impurities which enter with the crude. They may even contain impurities introduced for refinery reasons. Most of the solid matter is settled out, progressively and in stages, in one or more settling tanks. From the final tank, the fuel oil storage tank, (supplied with warming coils) the heavy liquid fuel passes in series through strainers, pump and heating coils, and then into a piping loop which runs around and through the refinery and returns to the tank. Branch piping loops are taken off this main fuel oil feed and return line to provide fuel for groups of heaters associated with any one process or plant area. Individual refinery areas may, therefore, be taken off-stream and returned to service without cooling down the main fuel oil loop.

The temperature to which a residual fuel oil is heated and circulated may vary from 220-600 F. depending upon its viscosity charateristics and the type of atomizing principle used in the burners. The pumping pressure level in the circulating line will be governed by the requirements for burner atomization selected, plus the expected frictional resistance through the extreme fuel oil distribution circuit.

Steam tracing of the main and secondary fuel oil loops may be a serious consideration depending upon local climatic conditions and the physical properties of extreme fuel to be fired.

Where the fuel oil melting temperature is high, as for asphalt or tar, it may be necessary to install a light flushing oil loop in parallel with the main and secondary fuel oil loops. Individual burners should be fired on flushing oil for a short period before any burner shutdown to clean and protect finely machined spray parts. Flushing oil physical properties and the pressure level in this circuit must, therefore, be suitable for such burner operation.

Burners and Combustion—The normal process of combustion requires that approximately 18 pounds of air be admitted through a burner to support the combustion of each pound of fuel. Residual fuels melt and solidify at higher temperatures than do the lighter grades of liquid fuel. They are therefore much more sensitive to the chilling effect of the large masses of combustion air. The atomized fuel particles present a large amount of exposed heat transfer surface to the cool combustion air, and the chilling effect of the air on the fuel particles is quite pronounced. The lighter residuals, such as Bunker "C," are not seriously hampered by this phenomenon and may be fired successfully on cold combustion air supplied to the burner by natural draft. On the other hand, atomized particles of high temperature melting point pitch, tar or asphalt, will tend to congeal on contact with cold combustion air. Such fine particles of congealed fuel do not burn to completion or burn at all with the result that the particles stick to and contaminate furnace internals or blow up the stack as a cloud of very black smoke. From the point of view of maintenance and air pollution, firing under such conditions can hardly be tolerated.

Residual fuels are being fired today in commercially available burner equipment with varying degrees of success. The burner designs which appear to fire the heavy fuels most successfully include one or more of the following advantageous features in their design to overcome the difficulties described in the previous paragraph:

(a) Short flame combustion, or combustion which starts as close as possible to the burner fuel atomizing device. Early combustion of the fuel releases sufficient heat to prevent the atomized fuel particles from congealing. Such early combustion may best be accomplished by supplying air to the burner under forced draft. With controlled air available to the burner designer and operator a rapid and uniform mixture of air and fuel is obtained resulting in immediate combustion and a short flame. To a lesser extent, early combustion may be achieved by special burner atomizer drillings and/or special design of air vane located in the burner registers. Supplementary fuel, such as gas, has been fired in the same burner and concentrically with heavier fuel oils to accomplish same result.

(b) The presence of substantial amounts of dense refractory material at the mouth of burner will improve combustion. Incandescent burner tile will re-ignite wayward fuel particles. The heavy refractory is capable of storing quantities of heat which minimize the chilling effect of the combustion air.

(c) Combustion air may be supplied to the burner registers preheated to a temperature corresponding to the melting point of the fuel. The chilling effect of combustion air is, therefore, eliminated by most direct means. The heat for the combustion air may be obtained by heat exchange with exit flue gas using any commercially available air preheater. An air preheater will improve overall heater thermal efficiency and usually justify the cost of its own installation if the heater is of any appreciable size.

(d) The fuel oil may be preheated to temperatures of 500-600 F. before being fed to the burner. The purpose being to store sufficient sensible heat in the liquid fuel to compensate, somewhat, for the expected cooling after atomization. High temperature superheated steam may be supplied to a burner, to achieve the same re-

Meet the Author

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sult, in a steam atomizing-type of burner.

(e) Mechanical or pressure atomizing burners are less desirable than steam atomizing for residual fuels, because they depend upon small diameter spray orifices and finely machined spray tips for proper atomization. Small diameter orifices tend to clog in operation and change the angle of the burner flame. Unless the spray tips in pressure atomizing burners are manufactured of specially treated alloy steels they rapidly change atomizing characteristics under the errosive action of the fine suspended solid matter always found in residual fuels.

Oil Heater Equipment—Burners and combustion, although discussed separately in the preceding paragraphs, are still a component part of the over-all oil heater equipment. A good residual fuel burner will help but cannot cure all of the ills of a poorly designed heater. The mere installation of residual fuel burners does not convert an existing heater into one generally suitable for firing on residual fuels.

Residual fuels, because of their nature, contain a concentration of all of the contaminants originating in the crude. After combustion these contaminants form products that are actively corrosive to furnace metal and refractory parts; or form slags and ash which deposit on heat absorbing surface to retard heat transfer and the passage of flue gas.

Figure 1 shows a cross-section of a heater specifically designed for firing on heavy asphalt. More than 60 heater units of this general design have been built in refineries around the world; they range in heating capacities up to 220 million Btu per hour each. Heaters of this design, operating in almost every type of refinery service, have averaged better than full year continuous runs while firing on the heaviest of residual fuels. Length of run is emphasized here because increased cost of maintenance and loss of production resulting from excessive down-time are the major economic factors deterring broader acceptance of residuals as fuel.

Heaters of the style shown on Figure 1, have been designed with burners and combustion systems ranging from the simplest natural draft firing arrangements up to those complete with forced draft and high temperature air preheat systems. The final selection of any burner and combustion system will depend upon local plant conditions and economics and the characteristics of the fuel. The general combustion and burner principles reviewed in earlier paragraphs would still apply. To further insure complete combustion of heavy fuels it is essential that the heater radiant chamber be properly proportioned and provided with a generous fraction of hot incandescent refractory wall surface to avoid a "cold" firebox. The burners, in the heater shown in Figure 1, are shown mounted horizontally and located high on the opposed end walls so that burner "dribble," if any, will fall clear of the burner and not foul the firing elements.

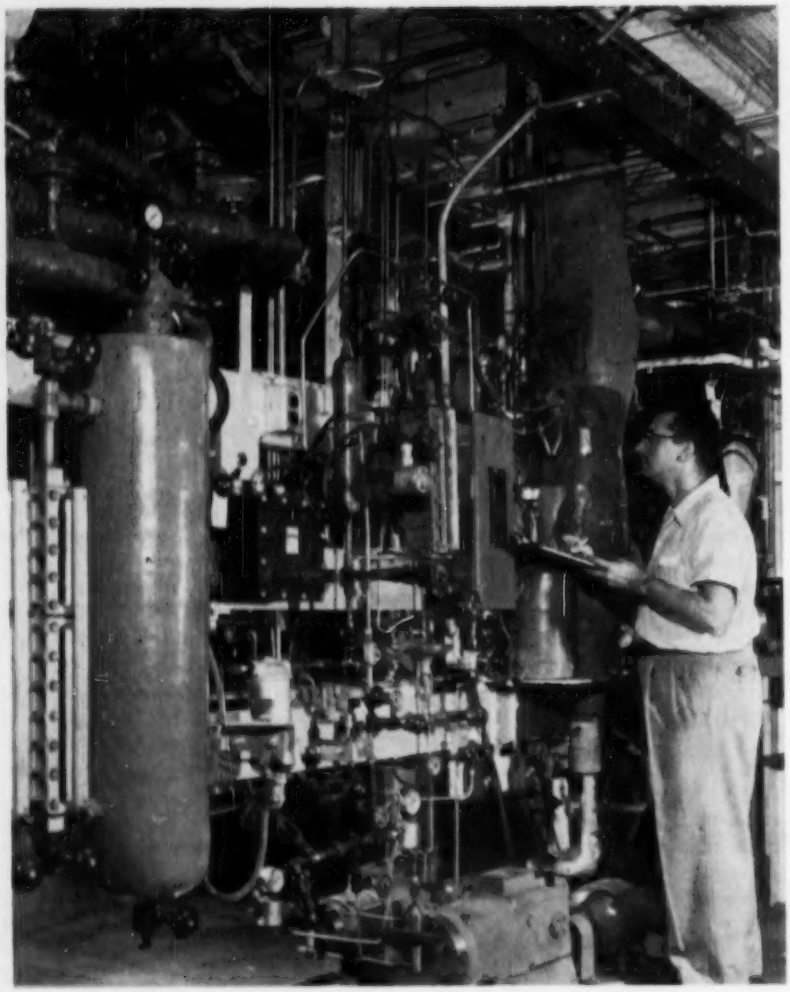
The principal design feature of the oil heater shown is that the corrosive and ash-laden products of combustion generated in the heater are withdrawn, downward, out of the radiant chamber without coming into contact with any of the radiant chamber metal parts, tubes or tube supports. By preventing this direct contact with flue gas, the radiant tubes are kept free of heavy slag deposits. In a like manner, the corrosive attack of vanadium and sulphurous oxides, on high chrome intermediate tube support castings is minimized in this most active temperature range. These oxides are usually present in very substantial quantities in the products of combustion of most residual fuels. Attack by these oxides on chromium bearing alloys is both severe and rapid. Direct attack by vanadium oxide, in particular, has been known to cause complete failure of high chrome alloy tube supports in a matter of only a few weeks under otherwise normal heater operating conditions.

The products of combustion are evacuated downward from the radiant chamber through a checkered refractory hearth which is of a material impervious to attack from the corrosive elements in the flue gas. The hearth tile rests loose on a series of support piers; the flue gas passage slots between the tile slabs may therefore be readily adjusted. The entire flue gas evacuation and flow pattern in the radiant chamber may be shaped by merely adjusting the slot width between the hearth tile. Positive control over the direction of flue gas flow in the radiant chamber prevents flue gas from coming in contact with and overheating any of the lower tubes in the side wall bank nearest the stack. A reasonably uniform radiant heat absorption pattern is obtained which makes it possible to heat two symmetrically arranged and parallel streams in the same chamber.

The hearth tile not only presents an incandescent refractory surface to the radiant chamber above, but creates a "drop-out" chamber beneath. The flue gases passing downward, between the hearth tile slots, make a full right angle turn into a low velocity, settling-out, storage chamber. The change in velocity and direction at this point is intended to disengage solid matter that may be entrained in the flue gas. The storage chamber is sized to accumulate quantities of solid matter over the full length of a run without interrupting general heater operation. The storage chamber is located near grade to facilitate cleaning during the shutdown period.

The products of combustion make another right angle turn, upward, and then for the first time contact metallic furnace parts, at the entrance to the convection or waste heat recovery section. By this time the flue gas temperature has been lowered to a point where the remaining corrosive elements are less active and the flue gas has been stripped of most entrained solid matter. In addition, the convection section is located to the side of the heater to permit full and convenient access for cleaning flue gas passages along the full length and height of the convection bank. Standard soot blowing equipment or steam lance doors may be provided along the side of the convection bank as a further insurance that the flue gas passages will be kept clear over the full length of the run.

Facilities for water washing the convection section from above, during shutdown periods, may also be included. Some convection deposits are soluble in water. These and most other deposits in the convection bank may be washed down by the mechanical action of a hot, slightly alkaline, water jet. The convection section is so arranged that wash water may be drained off at grade without coming in contact with or damaging any of the high temperature refractory materials. # #



This catalytic cracking unit can be operated by one man. Its reactor is two inches in diameter as compared to the 35-foot diameter full-scale reactors of some units.

Esso's Research Done in A Miniature Cat Cracker

THE SMALLEST continuous fluid "cat cracker" of the Esso Standard Oil Company will go back on stream later this month, following a shutdown of some six weeks, and after 12 hours of operation it will have produced the total of two gallons of gasoline.

The unit, located at Bayway Refinery, is the Process Research Division's newest pilot plant, and its scaled-down daily output is more than adequate for studies aimed at extending the scope of fluid catalytic cracking in new areas.

Everything about the pilot unit is small except its three-story height (if the height had been built to scale, the flow velocity of oil through the unit would have been affected). Its half-inch lines compare with lines eight feet across in some commercial units, and the pilot plant's reactor is two inches wide as opposed to the 35-foot wide full-scale reactors of some units.

It was several years ago that Process Research men began thinking in terms of the miniature unit. Until then, a three-barrel-a-day plant had served them for more than a dozen years as the chief instrument of cracking research.

The three-barrel unit had contributed importantly to Esso operations over the years. It proved out the fluid hydroforming process on a small scale, performed some of the early work on fluid coking, and showed that heavy feed stock could be used as successfully as light feed in catalytic cracking.

But this veteran pilot plant was expensive to operate, requiring three men a shift on its seven-day-a-week, 'round-the-clock schedule. The division wanted to free some of those men to tackle key research problems that had been piling up.

The decision was made to design a smaller, more automatically-controlled unit that could be operated by only one man per shift.

Process Research men built the entire unit except for certain of the control panels. This installation contained the first graphic control panel used in any of the Process Research Division's plants.

The principle of the old steamboat paddle wheel is used to measure and control the flow of spent catalyst from the reactor to the regenerator. This makes it easy to keep track of the catalyst as it is "paddled" along its route.

The unit was first started up early this year, and has made some 50 short-term runs so far. Expected difficulties, normal in any new piece of equipment as intricate as a cat cracker, caused a major turnaround to be pulled during the hot last half of July. Nevertheless, the turnaround was completed according to schedule and additional data have been obtained during subsequent runs. ==

New Tool . . .

Vapor-Phase Chromatography

Analysis of gases and volatile liquids is accomplished by the principle of selective sorption.

W. J. Podbielniak and S. T. Preston,
Podbielniak, Inc.,
Chicago

A typical commercial apparatus for chromatography analysis.

VAPOR-PHASE CHROMATOGRAPHY is a powerful new analytical technique for simple and rapid analysis of gases and liquids boiling up to 300 C. The separating principle is that of selective sorption in colums having up to 2000 plates, packed with solid adsorbent or with liquid solvent supported on inert packing. The method requires small samples (3 gas cc.), is rapid (10 to 40 minutes), accurate (1 to 4 per cent on component); its results in most cases equal or surpass those with spectroscopic methods; it is a logical supplement to distillation methods. First disclosed in 1941 by Dr. A. J. P. Martin, Nobel Prize winner, the method has only recently (since 1952) been developed by European researchers (England, Sweden and Czechoslovakia), consequently information on it is published mostly in foreign magazines, not generally available in the U. S. The present article is the first to review comprehensively all the available literature, including a simple explanation of the fundamentals of vapor-phase chromatography.

1. Introduction—The term "chromatography" was originally applied to the separation of colored plant pigments by selective adsorption. In the initial disclosure of this analytical method, Tswett[49,50,51] described the techniques for separating colored substances and recognized the potential application of the separating principle to non-colored substances, provided suitable methods of detection were available. In the original experiments, Tswett used a glass tube filled with calcium carbonate. The mixed pigments were added to the top of the column and eluted (i.e., leached or washed) through the column with a suitable solvent. Each of the various pigments moved through the column at a different rate, depending on its affinity for the calcium carbonate, resulting in the development of various color bands. Each band contained a different pigment and the height of each band was proportional to the quantity of pigment present in the original sample. From this modest beginning, chromatography has evolved into a method of analysis applicable to practically all liquids and vapors.

The term "chromatography" is now used as a generic description for the process of separation by differential sorption or solution, of the components of a flowing mixture, with respect

Meet the Authors

WALTER J. PODBIELNIAK has a background of 35 years in the chemical and petroleum industries. While still a student at the University of Michigan, he was recruited by one of his professors to join Phillips Petroleum Company's new research group which was investigating analytical methods for natural gas and gasoline. Later, with his own ideas about analytical equipment, Dr. Podbielniak set out on his own, making the first installations of his fractional analysis equipment. In 1929 he opened a testing laboratory in Tulsa and in 1934 moved to Chicago where his plant and laboratory are now located. For his work in natural gasoline, NGAA in 1951 presented him with the Hanlon Award.

S. T. PRESTON is Dr. Podbielniak's assistant. He previously was an instructor for the NGAA's Low Temperature Fractional Analysis School and one time taught petroleum engineering at the University of Texas. He also served California Research Corporation, working in its Natural Gasoline group.

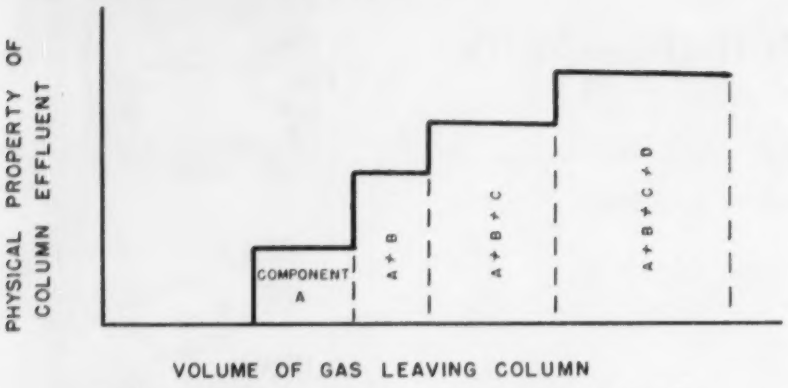


FIGURE 1—The frontal analysis mixes all components except the first.

to a stationary solid or liquid medium. Various forms of chromatography have been developed as analytical procedures, including (a) liquid chromatography (mobile phase is liquid while stationary phase is either solid, or an immiscible liquid supported by an inert solid), (b) paper chromatography, and (c) vapor-phase chromatography (mobile phase is gaseous while stationary phase is either solid or a non-volatile liquid supported by an inert solid). The following discussion is limited to vapor-phase chromatography only.

The two general mechanisms used to separate the components of a sample in a vapor-phase chromatographic column are (1) differential adsorption and (2) differential solution (or "partition"). The choice between the adsorption and partition methods depends on the nature of the components to be separated. The apparatus and techniques are essentially identical, differing only in the choice of material used to fill the chromatographic column. Activated forms of charcoal, alumina, or silica gel are commonly used in adsorption columns, while an inert solid (such as a filter-aid processed from diatomaceous earth) impregnated with a non-volatile liquid, is used in partition columns.

Separation of the components of a mixture by the partition method was initially disclosed in 1941 by Martin and Synge.[41] This development expanded the scope of the chromatographic method and made possible the rapid analysis of substances of considerably higher boiling points. Much of the development of the chromatographic method of analysis is due to the contributions of a few investigators, including A. T. James, A. J. P. Martin and C. S. G. Phillips,[20,21,22,23,24,25,26,27,28,29,41,43,44,45] in England. The principal contributions other than those from England include the work of Janak[30,31,32,33,34,35,36,37,38,39] in Czechoslovakia, based on the use of carbon dioxide to elute components from an adsorption column, with subsequent solution of the carbon dioxide by caustic at the column discharge, and the comprehensive work of Claisen[6,7] in Sweden on all phases of the analytical method. It is known that considerable research work on vapor-phase chromatography has been done in the laboratories of Imperial Chemical Industries Ltd., British Petroleum Company, American Cyanamid Company, Monsanto Chemical Company, Tennessee Eastman Company, Standard Oil Company of Indiana, and Shell Development Company. However, relatively little of this work has been reported to date in the technical literature.

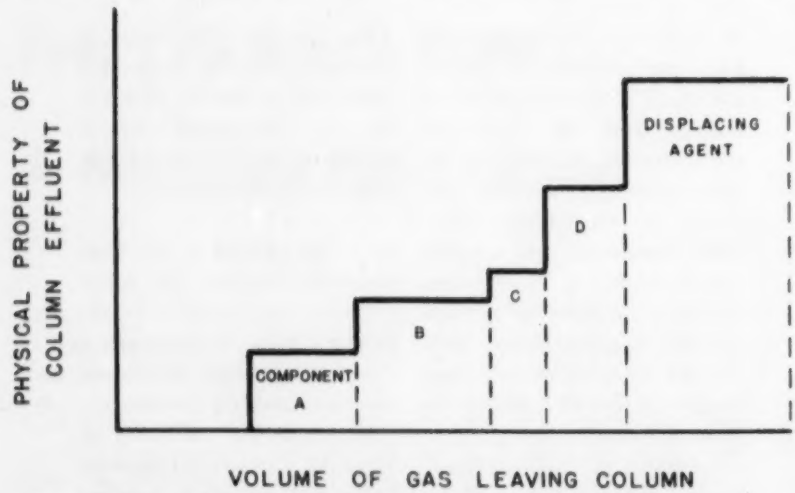


FIGURE 2—In some displacement analyses, the "cutpoints" between adjacent components are difficult to estimate.

There are three general techniques of analysis, which may be used with either a partition or adsorption column, namely: (1) frontal, (2) displacement and (3) elution.

1. Frontal analysis of a mixture is accomplished by forcing a quantity of the sample (in excess of that required to saturate the column) through the column. Prior to entry of the sample, the chromatographic column is filled with some indifferent gas, which is subsequently displaced. As the mixture passes through the column, selective sorption retards the passage of the more strongly sorbed components, thereby permitting the component having the least affinity for the column packing, to emerge from the column in a pure state. The volume of the mixture which must be passed into the column before the first component appears in the column effluent is referred as the "retention volume" of that component. The identity of this component in the column effluent is established by the measurement of some physical property. The concentration of this component in the mixture is determined by the retention volume and a knowledge of the adsorption isotherm. Subsequent components of the mixture appear in the column effluent in order of increasing affinity for the column packing, but each component after the first is mixed with all of the components preceding it. Thus, at the first break, the first component issues from the column in a pure form, while after the second break a mixture of the first and second components issues from the column, etc.

It is the fact that components after the first are mixed which makes this method relatively undesirable for analytical purposes. The volume versus composition curve for the eluent ("chromatogram") resulting from the frontal analysis of a four-component mixture is illustrated in Figure 1. This method of analysis is exemplified by the charcoal test procedures currently specified by the Natural Gasoline Association of America[1] and the California Natural Gasoline Association.[5] The theory and techniques of frontal analysis have been described by Claisen and others.[6, 7]

2. Displacement analysis is, as the name implies, accomplished by introducing a sample in the column and displacing the sample with a component which is more strongly sorbed than any of the components of the sample. The sample is separated by selective sorption as it moves through the column, into bands, each of which contains one component. The components leave the column in order of increasing affinity for the column packing. The identity of each component is established by the continuous measurement of some physical property of the column effluent. Since each component tends to issue from the column in a pure state, all components are susceptible to identification. The volume of each component can be determined as it leaves the column, making possible the calculation of the concentration of each component of the sample.

There are two limitations to the displacement method of analysis. Since one component of the mixture is immediately followed by another there is an intermediate mixed fraction. This imperfect separation makes it difficult to estimate the "cut-point" and thus influences the accuracy obtainable. The identification of some components may be difficult or impossible by conventional detection methods (thermal conductivity and gas density), if two components having similar physical properties are displaced consecutively. An apparatus based on the displacement analysis method was described in 1943 by Turner[52, 53, 54] and more recently by Guild and Clough.[9, 18, 19] A charcoal adsorption column was used to separate components. Samples were displaced by mercury in the early version and by organic vapors in the later model. Displacement of samples from an adsorption column by means of a stream of nitrogen saturated with an organic vapor, has been reported.[16, 43]

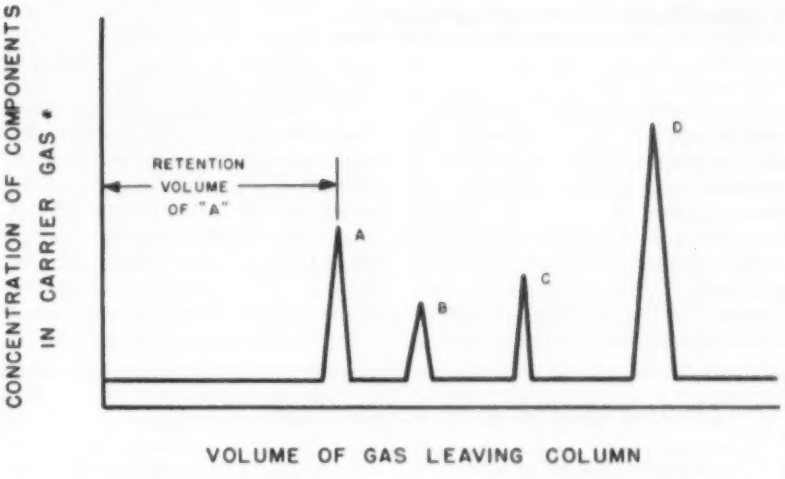

CONCENTRATION OF COMPONENTS IN CARRIER GAS *
RETENTION VOLUME OF "A"
A
B
C
D
VOLUME OF GAS LEAVING COLUMN
* AS DETERMINED BY THE MEASUREMENT OF SOME PHYSICAL PROPERTY SUCH AS THERMAL CONDUCTIVITY

FIGURE 3—Contamination by adjacent components usually does not exist during an elution analysis.

A typical chromatogram resulting from displacement analysis is shown in Figure 2.

3. Elution analysis is accomplished by introducing a sample and causing the components of the mixture to move through the column, by passing a carrier gas through the column. Each component moves at a rate depending on its "partition coefficient" (solubility in the stationary phase) or affinity for the adsorbent. In this method of analysis, components are identified by the retention volume (volume of carrier gas passed from the start of the analysis until the component reaches the column effluent as indicated by the detector). A typical chromatogram for an elution analysis of a 4-component mixture is shown in Figure 3. The area (A) under each peak is given by:

$$A = \int_{V_1}^{V_2} c \, dv$$

The area therefore represents the amount of each component (volume x concentration) and may be used to compute quantitative results. In this method of analysis, the components eluted from the column are generally free from contamination by adjacent components. Although until recently, elution analysis has been used principally with liquid chromatography, this technique is exemplified by the air fractionated charcoal test procedure described by King[40] and Gard.[14]

2. Apparatus and Techniques — Of the various methods of vapor-phase chromatography described, the partition elution methods offer certain dis-

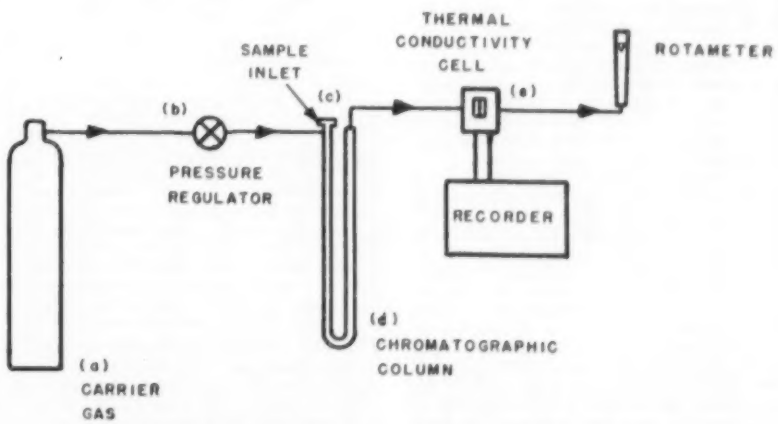


FIGURE 4—Simplified diagram of elution analysis apparatus.

tinct advantages over other methods of analysis and will be considered in detail. In general an elution method is preferable to displacement because at the completion of an elution analysis, the column is immediately ready for another sample while with the displacement method, the displacing fluid must be removed, involving additional time, manupulation and equipment.

The choice between an adsorption elution or partition elution method depends on the nature of the sample to be analyzed. The quantity of material adsorbed by the principal adsorbents (charcoal, alumina, and silica gel), and consequently the retention volume, increases rapidly with increasing molecular weight. The relatively large retention volumes of hexanes and heavier, on adsorbents, result in longer time of analysis, thereby losing partially the principal advantage of the chromatographic method, namely that of speed with useful accuracy. On the other hand, the relatively slight solution of gases as light as methane in the non-volatile liquids used as stationary phases in partition columns, results in these gases being eluted too rapidly to permit accurate identification and separation. In general it will be found preferable to analyze mixtures of light gases (as methane through pentanes)

These parts are essential . . .

• **Carrier gas**—Three gases have been used most often by the researchers in this field, namely: nitrogen, helium and hydrogen.

Helium and hydrogen have high thermal conductivities (6 to 7 times that of nitrogen) consequently they show a very high sensitivity to small concentrations of eluted components. The fact that all eluted components have lower thermal conductivities is an advantage as all peaks will appear on the same side of the base line (representing the carrier gas). However, both helium and hydrogen tend to diffuse rapidly into the fronts of components being eluted from the column with some loss of sharpness of separation. The use of slower diffusing nitrogen requires greater sensitivity in the detection circuit, but since thermal conductivity cells are available of sufficient sensitivity, nitrogen will probably be used for most analytical work. Hydrogen or helium may be substituted when analyzing for trace components since the electrical output of a thermal conductivity circuit, with equal filament temperatures, is about 50 times greater for hydrogen than nitrogen.[5a]

• **Pressure controller**—Since components are identified by retention volume (usually measured by time), it is essential to maintain a constant flow rate throughout the analysis. Minor fluctuations or pulsations in the flow of the carrier gas will generally be reflected as an instability in the detector output. Flow rates used vary from 5 ml/min. to 150 ml/min. depending on the type of sample being analyzed. A flow indicating device such as a rotameter is frequently included in the apparatus, but is not essential for accurate analyses, since the column may be calibrated at a given rate and used at this rate, or an internal standard as described by Ray[6, 17] may be used.

• **Sample Inlet**—The small samples required for analysis by this method (one to 15 ml. of gas, and 0.1 to .001 ml. of liquid) may be introduced by any of several methods. Gaseous or liquid samples may be injected into the column by means of a hypodermic syringe, through a self-sealing rubber cap, located at or near the inlet to the column. Gas samples may also be introduced to the column by means of a bypass in the carrier gas line, just ahead of the column. Liquid samples may be introduced by opening the inlet to the column momentarily and inserting a short length of capillary metal tubing (with suitable handle), which has been filled with sample by capillary action. Sample is released from the tube by touching end to a small wad of cotton in the top of the column. The momentary interruption of the flow of carrier gas will cause a peak to be recorded (if thermal conductivity cell is flow sensitive) which serves as a convenient recorded reference mark, indicating the start of the analysis.

• **Chromatographic Column** — The columns in general use vary from three to eight feet in length, of stainless steel or glass, may be folded, or spiral in form, and three to ten mm. i.d. Adsorption columns are packed with activated forms of charcoal, silica gel, or alumina, 40 mesh or finer. Partition columns are packed with an inert solid impregnated with a suitable non-volatile absorptive liquid.

The inert packing should be sized by sedimentation, discarding the fines. After drying, the inert packing is impregnated with the stationary phase liquid. Previous investigators have used a variety of liquids such as: normal dodecane, dinonyl phthalate, benzyl diphenyl, hexatriacontane,[3] tri-isobutylene,[4] silicones, glycerol, liquid paraffin, and others. The stationary phase liquid may be distributed over the packing by thorough mixing, or may be mixed with a volatile solvent and added to the packing, the solvent being removed subsequently by evaporation.

Since the retention volume of a particular component is influenced by the temperature of the chromatographic column, the accurate identification of components requires that the column be held at a constant known temperature. Once the order of elution for a particular column is established, it is only necessary to maintain a constant column temperature. The use of internal standards (a known material added in known concentration to the original sample to give a reference peak on the chromatogram) further reduces the necessity for close temperature control.

The effect of temperature on column efficiency is not definitely established but at least one investigator[20] has reported that higher efficiencies are obtained at higher temperatures. Higher column temperatures are required to analyze high boiling components (column temperature may be 50 to 100 C. below the boiling point of the component, due to dilution with carrier gas). Partition chromatographic columns have been operated at temperatures as high as 300 C.[11, 12] In the analysis of very high-boiling or heat-sensitive substances, it will occasionally be desirable to operate the chromatographic column at reduced pressure. However, a column packed with diatomaceous exhibits a considerable pressure drop (200 to 500 mm. Hg. depending on length) rendering operation under vacuum difficult or impossible. The use of a coarser supporting solid (NaCl) has been reported as a satisfactory solution to this problem.[12]

• **Detectors** — Various methods of detecting the concentration of components in the "eluent" (mixed gas leaving the column) have been used including thermal conductivity measurements, gas density (flow impedance bridge), surface potential,[14, 17] infra-red spectrometer, and titration where eluted substances exhibit acidic or basic reactions.[20] The thermal conductivity method has been used by more investigators than any other detection method, because of its simplicity and high sensitivity. The cell must be highly sensitive and must respond instantaneously to rapid changes in composition. Sensitivity to flow rate should be the minimum compatible with the requirement of instantaneous response. Most commercial thermal conductivity cells are constructed to permit gas from the flow line to enter the cell cavity by diffusion, this affording satisfactory speed of response for most requirements. However, chromatographic analysis requires specially designed cells of materially faster response. The various forms of cells described in the literature, in connection with chromatographic work, feature flow of all the gas through the cell cavity. Typical designs are described by Patton,[15] Ray,[6] and others. In order to follow rapid changes in composition, a recorder with a pen speed of one to two seconds full scale travel should be used. For maximum versatility, the output of the thermal conductivity circuit should be attenuated in even steps. The thermal conductivity cell must be maintained at a uniform temperature.

by adsorption elution, and heavy vapors (as pentanes through octane and heavier) by partition elution.

The basic form of the apparatus used for elution analysis is shown in Figure 4. The essential parts are: (a) a source of carrier gas, (b) a pressure regulator capable of giving a constant flow rate, (c) a sample inlet, (d) the chromatographic column and (e) the detector, usually a thermal conductivity cell. See box for details on each part. A typical commercially available chromatographic apparatus is illustrated on the first page of this article.

3. Applications of Vapor-Phase Chromatography — Elution chromatography has been used for the analysis of the hydrocarbons methane through hexane,[4, 42] isomeric hexane and hexenes,[48] pentanes through n-nonane and cyclo-octane, including all paraffin components, also many of the olefins, naphthenes and aromatics,[3] in this general range. Gases, such as argon, nitrogen, oxygen, hydrogen, neon and krypton have been analyzed,[2, 10, 15, 56] using adsorption columns. Operating at elevated temperatures, the C_{12} to C_{22} fatty acids have been separated and analyzed.[11, 12] By the development of special techniques, it has been possible to use vapor-phase chromatography to identify polymers (natural and synthetic rubbers).[13] Larger diameter columns, up to 1" and 20 feet long, have been constructed[12] for scaling up sample size to grams, although with longer time requirements.

It will be noted from the above reports, that the versatility of this general method is outstanding, encompassing the full boiling point range of gases and vaporizable liquids (although not necessarily in only one type of column or analytical operation) and making effective use of many highly selective polar and other solvents, as well as chemical reagents[3, 4] to accomplish separations impossible by distillation or other methods. Undoubtedly, many more applications will be made, with the discovery of more effective solvents and with more experience with the method.

4. Accuracy Considerations—Since the vapor-phase chromatographic method is relatively new, its accuracy limitations in research and in routine analytical use have not been reliably determined as for older methods. While the sharpness of separation of components may be very high, due to the high separating efficiency (equivalent up to 2000 theoretical plates), inaccuracies in the quantitative determination of components may be caused by variations in the flow of carrier gas, transient responses of the detector, etc.

The apparently most objective statements on the general accuracy of the method indicate from 1 percent to 4 percent[40a] deviation on the component against synthesis, the lower figure corresponding usually to separations by partition columns and the higher to adsorption separations. It has been stated that the results in most cases equal or surpass those obtained with spectrographic methods in accuracy, as well as in speed; presumably on relatively narrow range fractions. It is difficult at present to evaluate the accuracy of the method on complex full boiling point range materials, as usually handled by distillation methods. In any case, the attainable accuracy is adequate for a great many practical applications, and this fact coupled with speed and with relative simplicity of both apparatus and its operating technique, makes the new analytical method promising both in research and in the routine industrial analytical laboratories.

5. Correlation With Other Analytical Methods — As noted above, the chromatographic method not only comes close to being "a poor man's spectrograph," as it has been termed, but is outstanding in its versatility, simplicity and potential for much practical improvement. There will of course remain many analytical problems, where infra-red and mass spectrography will be preferred, or where these diverse methods will advantageously supplement each other.

In relation to analytical distillation, the latter has always required supplementary analyses on fractions inseparable by distillation, due to formation of azeotropes, very small difference in boiling point, etc. Here, vapor-phase chromatography fills the bill uniquely, perhaps better than any other supplementary method. Also, for the simpler fractions, and for determination of specific components in complex mixtures, etc., vapor-phase chromatography is beginning to compete with analytical distillation, having the advantages of simplicity, and not handicapped with high reflux ratio requirement.

However, analytical distillation is still the only method for handling sizable samples, with physically separate fractions of convenient size, applicable to full boiling point range samples, no matter how complex, etc. In low-temperature analytical distillation of natural and cracked refinery gases, the natural combination seems to be that of the highly developed low-temperature fractional distillation apparatus, of proven high accuracy and handling samples of 2 to 20 liquid ml., with the vapor-phase chromatographic apparatus to simultaneously and expeditiously resolve the cracked C-4, and perhaps other ordinarily difficult and time-consuming fractions, without need for any other supplemental methods. Thus, the high accuracy of the one method and the special resolving power and speed of the other may be combined.

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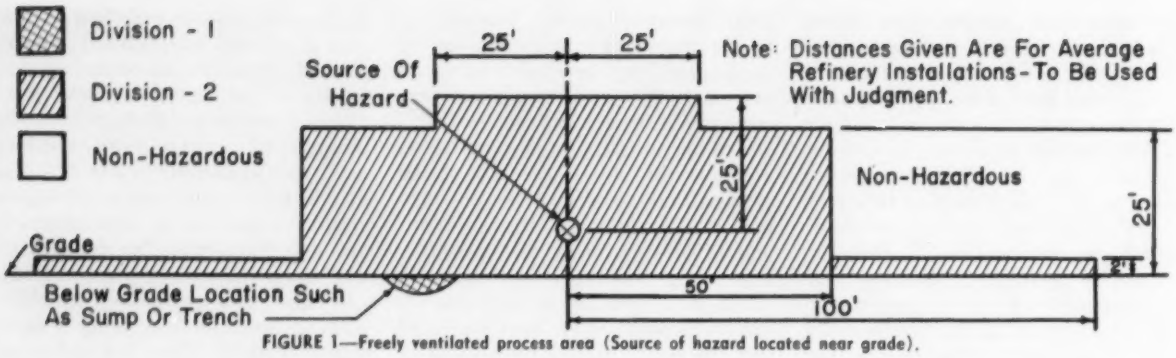

FIGURE 1—Freely ventilated process area (Source of hazard located near grade).

How To Classify Hazard Areas

Here is the background on the American Petroleum Institute RP-500 for classification of hazardous areas for electrical installations.

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THE RAPIDLY increasing use of electric power in the petroleum industry and the relatively higher costs of special equipment and skilled labor emphasize the need for clear understanding of the requirements for safe, economical design. The presence of combustible materials introduces problems that are not encountered in most electrical installations. Special precautions are required to insure that electrical installations for the petroleum industry do not create fire and explosion hazards. This concern over the fire and explosion aspects has tended to obscure the fact that electrical installations present other types of hazards of an equally serious nature. In the oil industry these hazards are:

Fire and explosion
Electric shock
Power failure

It is difficult and pointless to attempt to say which is number one. All are serious. A properly designed electrical installation recognizes and protects against all hazards. Unfortunately, no single type of electrical equipment enclosure is best in all respects. General-purpose type equipment, for instance, is adaptable to the finest in relaying and automatic controls and thus is the best insurance against a power failure.

But when considered from the point of view of fire and explosion hazards, general-purpose equipment is totally inadequate. On the other hand, explosion-proof equipment correctly designed and manufactured, properly installed, and carefully maintained is best against the dangers of fire and explosion. But explosion-proof equipment does not have the protection against shock provided by the safety interlocks, the isolating barriers, the drawout features, and the working clearances found in general-purpose equipment. General-purpose equipment is inexpensive. Explosion-proof equipment is expen-

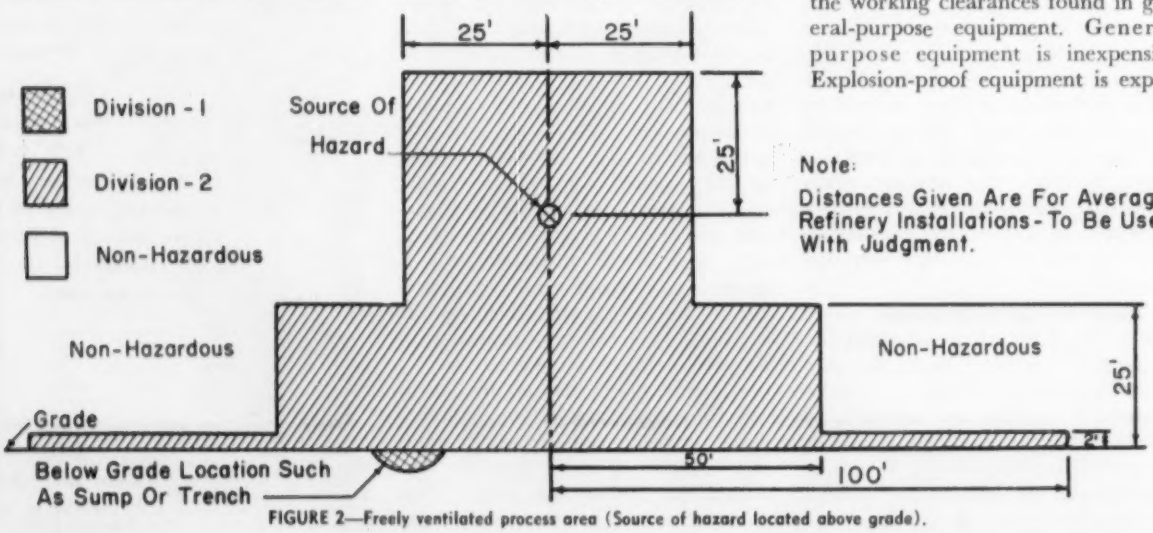


FIGURE 2—Freely ventilated process area (Source of hazard located above grade).

sive. To use explosion-proof equipment where it isn't necessary is spendthrift. To use general-purpose equipment where it isn't safe is foolhardy. The safest installation takes full advantage of the best features of each type. However, this approach is possible only if the degree and extent of the areas of hazard are clearly defined.

There are many practical reasons why electrical installations, even though the construction is fully explosion-proof, should be held to the minimum in hazardous areas. From personal observation of plants on an industry-wide basis, there were found countless examples illustrating the difficulties of adequately policing extensive electrical installations in hazardous areas. Such things as explosion-proof enclosures that are in service with the cover bolts loose or missing, or sometimes even with the cover gone altogether, are not unusual. Everyone is familiar with the adaptor or cheater that most mechanics carry to convert explosion-proof receptacles to the ordinary garden variety household type. This is common during refinery unit shutdowns and in many, many cases allowed to remain when the unit goes on stream again.

A close inspection of almost any refinery would probably uncover similar examples. Such things point up the fact that no matter how carefully an installation is designed and constructed, the safety features are easily nullified. Therefore the safest approach is to minimize electrical installations in hazardous areas.

It is astounding how much confusion, disagreement, and inconsistency has surrounded the problem of classifying locations as Division 1, 2, or non-hazardous. Equal chaos prevails on determining the extent of a hazardous area. Opinions have ranged from the "everything within the fence" philosophy to the 25-foot rule. Disagreement and inconsistency between different organizations or different geographic areas is at least understandable. Inconsistencies within the same organization resulting in contradiction on the same installation are beyond explanation. Yet they are common.

In 1951 the API's Sub-Committee on Electrical Equipment under the chairmanship of the author, was asked to undertake a project intended

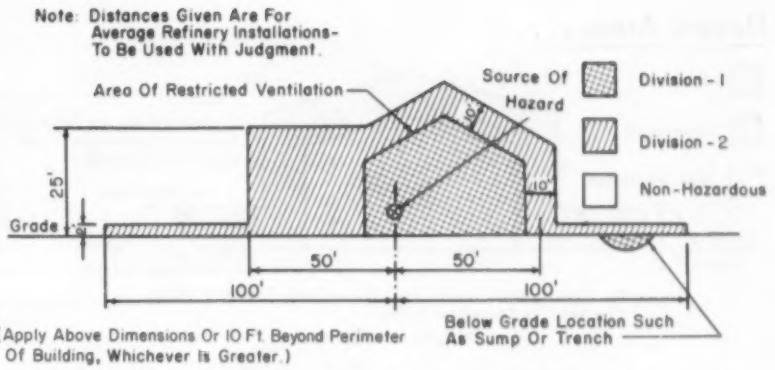


FIGURE 3—Process area with restricted ventilation.

to develop a sound basis and understandable procedure for determining the existence, classification, and extent of hazardous areas in petroleum refineries. This work culminated early in 1955 with the publication of API Recommended Practice RP-500, Classification of Refinery Areas for Installation of Electrical Equipment.

The first step in developing RP-500 consisted of a survey of the practices of the refining companies participating in API. At that time it was hoped that such a survey would indicate that a substantial majority of the industry was following identical practices. The fact that a majority followed a particular practice would be taken as evidence of its soundness and thus the job could be reduced to one of determining and formalizing the practice of the majority. The first survey indicated total disagreement. A second survey was made, but the results were the same. About this time it became obvious that the only thing to do was to start from the bare fundamentals in an attempt to reason our way to the correct answer, of course tempering the reasoning with the judgment and experience of the committee members.

Accordingly, it was decided that a broad approach was the proper one, and that the recommendations should be made sufficiently conservative so that variations in small details would not alter the soundness of the solutions.

It is intended that in using these recommendations that sound judgment accompany the use of this material; where, in the opinion of the engineer, particular conditions are better or worse than average, then the recommendations of RP-500 should be modified appropriately. RP-500 is not an attempt to rewrite or otherwise supersede the National Electrical Code. Rather it is intended to serve as a supplement. The NEC is quite specific on the type of equipment to be used in hazardous areas. Once the degree and extent of hazard have been determined, there is little difficulty in understanding what the requirements are for equipment. The real problem is determining the existence, degree, and extent of a hazardous area. The NEC has established certain criteria for making this determination, and RP-500 attempts to apply these criteria to typical oil refinery installations.

Article 500 of the NEC deals with hazardous areas. It recognizes two types of areas directly and a third by indirection. These areas are:

Division 1 Areas—The criterion for these locations is that they may be hazardous under normal conditions.

Division 2 Areas—The criterion for these locations is that they may become hazardous only under abnormal conditions—such as the failure of a gasket, etc.

Non-hazardous Areas—These are locations that cannot be classified as Division 1 or 2.

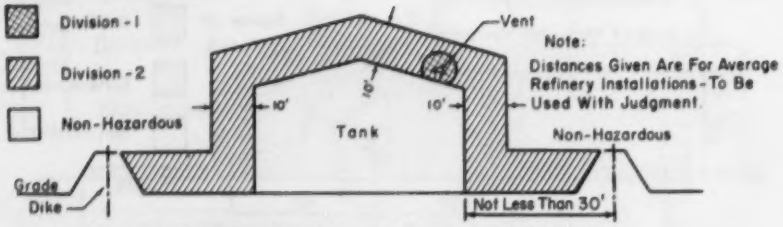
The terminology and criteria of the NEC are used in the definitions developed in RP-500.

Three conditions must be satisfied in order to have a fire or explosion. The conditions are:

1. A flammable material must be present.
2. The flammable material must be present in the proper proportions to ignite.
3. A source of ignition must be present.

The first thing that must be done is to decide what is a flammable material. RP-500 proposed that ma-

Hazard Areas . . .



Note: For Floating Roof Tanks, Area Above Tank Roof And Within The Shell, Is Classified Division 1.

FIGURE 4—Tank farm.

terials be judged flammable if they meet the following:

1. Any material being handled, processed, or stored at a temperature above its flash point.
2. All materials with a flash point less than 150 F.

The basis for the first rule is obvious. The second rule is based on conservative judgment backed by the combined experience of the sponsors.

Whether a flammable material can be present in proper proportions to ignite leads to endless complications. This report assumes that if a flammable material is present, it will be in a state to ignite. This assumes the worst and thus is conservative. Generally if flammable materials are handled in an area, there is a possibility of their getting into the air either normally or as the result of some abnormal occurrence. At this point "abnormal" must be defined. Abnormal is used here in a limited sense. It is intended to cover those things that can go wrong short of a major catastrophe. It is generally recognized that it is not possible to protect against such extremes. Thus, except for a few special cases which are spelled out in RP-500, any location in which a flammable material is handled, processed, or stored is hazardous.

As stated previously, the NEC criterion for Division 1 is whether the location can be hazardous under normal conditions. For Division 2 the criterion is whether the location can be hazardous only under abnormal conditions. "Normal" does not necessarily mean the situation that prevails when everything is working properly. For instance, an operation might be so sensitive to control that frequent operation of the relief valves occurs. This would be considered "normal" and if the valves might release flammable material to the atmosphere, the location would be classed as Division 1.

On the other hand, if the operation of the relief valves occurred infrequently under unusual conditions, it would not be considered "normal." Similarly there are cases where frequent maintenance and repair are necessary. This would be viewed as "normal" and if flammable material might be released as a result of the maintenance, the location would be Division 1. However, if repairs were not usually required between turnarounds, the need to do repair work would not be considered "normal."

The hardest part is to arrive at a basis for determining the extent of a hazardous area. Perhaps a good beginning is to start with the fact that hydrocarbons are generally heavier than air. Their behavior in air is somewhat like a liquid in that they tend to sink to the ground, billow along the ground, and seek and settle in low spots. This liquid-like behavior leads to several conclusions.

1. In the absence of walls, enclosures, or other barriers, and in the absence of air currents or similar disturbing forces, it must be assumed that a vapor will travel equally in all directions. Thus, if the source of hazard were a single point, the area covered by the vapor would be a circle.
2. The locations most likely to be hazardous are below grade. Those at grade are next most likely. As the height above increases, the liklihood of hazard decreases.
3. Safe distances or clearances in the vertical direction are much less than in the horizontal direction.

Another concept that must be understood is that there is always a twilight zone between a Division 1 (normally hazardous) location and a non-hazardous location. Obviously one side of an imaginary line cannot be normally hazardous and the opposite side never be hazardous. There has to be a zone that could be hazardous under abnormal conditions. These conditions might be unfavorable air currents, an abnormally large release of flammable material, and so on.

It is quite easy to acquire an exaggerated conception of the extensiveness of Division 1 locations. The probable reason for this misconception is that it is very hard to refrain from thinking in terms of what could happen if a major piece of equipment let go. It takes constant mental discipline to think in terms of what can happen under *normal* conditions. Surely the failure of a major item of equipment is not a normal condition. Such an occurrence is abnormal in every sense of the word. This does not mean the abnormal is not a consideration in the overall picture. That is the significance of Division 2—the twilight zone that always exists between a source of hazard and a non-hazardous area.

Correctly evaluated, a refinery in-

Meet the Author

LESTER M. GOLDSMITH, since 1951 general manager of The Atlantic Refining Company's Engineering and Construction department, has been with the company since 1916. As chief engineer during World War II, he was retained by the War Department as a consultant, served on the National Defense Research Committee, and was loaned to the British War Ministry, to help develop a flexible pipeline across the English Channel. He is a fellow of AIEE and ASME, a member of more than a dozen professional organizations, author of some 20 technical articles, and a registered engineer in five states. In 1939 he received the ASME's Melville Medal.

STEP 1—Affirmative Answer to Any of the Following Indicates the Existence of a Hazard:	
Is the Presence of Flammable Liquids or Vapors Having Flash Points Less than 70 F. Likely?	No
Are Any Flammable Liquids or Vapors Having Flash Points Under 200° F. Likely to be Handled, Processed, or Stored at Temperatures Above their Flash Points?	Yes

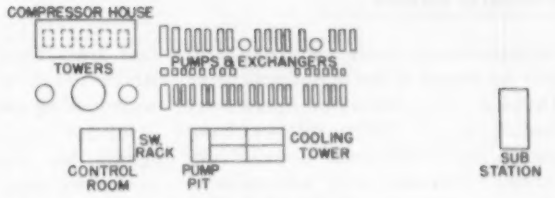


FIGURE 5

STEP 2—Affirmative Answer to Any of the Following Indicates Existence of Division 1 Location:	
Is a Hazardous Gas or Vapor Concentration Likely to Exist in the Air Under Normal Operating Conditions?	No
Would a Flammable Atmospheric Concentration Occur Often Because of Maintenance, Repairs, or Leakage?	No
Would a Failure of Equipment be Likely to Cause a Simultaneous Electrical System Failure?	No
Is the Area Not Freely Ventilated and One in Which Flammable Materials are Handled in Other than Tight Equipment or Containers?	Yes Compressor House
Is the Area Below Grade?	Yes Pump Pit

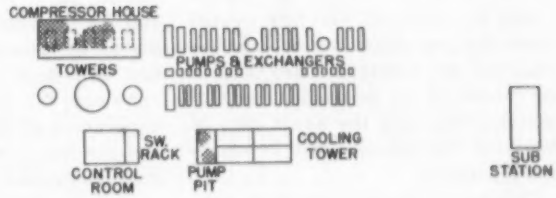


FIGURE 6

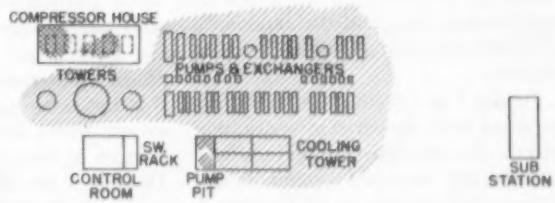


FIGURE 7

STEP 2—Affirmative Answer to Any of the Following Indicates Existence of Division 2 Location:	
Is the Location Freely Ventilated and with Flammable Materials Handled in Closed Systems (Other than Tight Piping Systems) From Which Escape Would be Abnormal, or Stored in Other Than Closed Containers?	Yes Except Compressor House
Is the Area Next to a Division 1 Area, or Can Vapor be Communicated to it Through Trenches, Ducts, Etc.?	Yes
If Positive Mechanical Ventilation is Used, in Event of its Failure or Abnormal Operation Could a Hazardous Vapor Concentration Build Up?	No

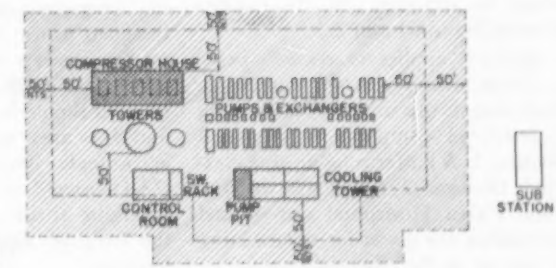


FIGURE 8

STEP 3—Determination of the Extent of the Hazardous Areas:
The Extent of a Classified Location is Determined by Applying the Recommended Distances Given in Fig. 1 Through Figure 4
Within an Area Extending 50 Feet From All Equipment the Vertical Extent of the Division 2 Location is 25 Feet Above Grade or Equipment Whichever is Higher. Within the Outer 50 Foot Band the Vertical Extent is 2 Feet Above Grade.

STEP 4—Determination of Proper N E C Grouping of Atmospheric Mixtures:
As Only Hydrocarbons Commonly Encountered in Refineries Would be Present the Proper N E C Atmospheric Grouping is Group D.

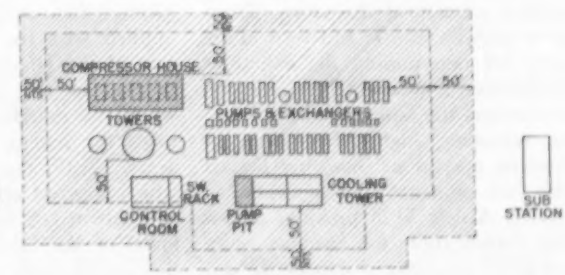


FIGURE 9

stallation in a freely ventilated area will be found to be a multiplicity of Division 1 locations of extremely limited extent. What releases flammable materials under normal conditions? Probably most numerous of offenders is the packing gland. RP-500 concludes that although Division 1 locations may exist around packing glands, in freely ventilated areas the extent of the hazard is so small it may be ignored. Glands located where the free dispersion of vapors is restricted are different. Here there is the chance of the flammable material accumulating, and the whole area of restricted ventilation should be classified Division 1.

Clearances recommended in RP-500 are presented graphically. These recommendations have been based on a careful weighing of all pertinent factors in the light of the available experimental data and the experience of a large segment of the oil refining industry.

Figures 1 and 2 cover refinery process areas with unrestricted ventilation where flammable materials are handled only in closed systems. It will be seen that the extent of Division 1 locations is negligible for above-grade locations. All areas below grade are considered Division 1. The extent of Division 2 locations may be determined by applying the clearances given in Figures 1 and 2.

Figure 3 applies to refinery process areas with restricted ventilation. Note that in this area the entire area of restricted ventilation is classified Division 1. A buffer zone or area classified Division 2 surrounds the Division 1 area. Horizontal and vertical dimensions are given for determining the extent of the Division 2 area.

Figure 4 applies to storage tanks and indicates the only Division 1 areas are the interior vapor space of the tank and the exterior area in the immediate vicinity of the vents. Clearances both horizontal and vertical are given for determining the extent of the Division 2 area which is indicated to surround the tanks. Note the warning regarding high filling rates or blending operations involving liquids with flash points of 70 F or below.

NEC Article 5125 provides a specific classification for loading racks and gives clearance distances for determining the dimensions of the classified area. Thus RP-500 recommends Article 5125 be used when dealing with loading racks.

RP-500 contains a four-step procedure for classifying refinery locations. The steps, in the order in which they are taken, are for the purpose of establishing the existence of a potential hazard, for determining the degree of potential hazard, for determining the extent of hazardous area, and for determining the NEC grouping of the atmospheric mixture. The first two steps consist of a series of questions; the third step concerns the application of Figures 1 through 4; and the fourth step involves checking the flammable material in question against the NEC grouping.

By way of illustrating the use of this procedure, consider Figure 5, which is a typical refinery unit. The lower portion of the figure contains the questions making up Step 1. Since the answers are affirmative, we conclude a potential hazard exists. Figure 6 is the same block plan as Figure 5 except the questions making up the portion of Step 2 intended to test for Division 1 are shown. This operation indicates that Division 1 hazards exist in the compressor house and cooling tower pump pit. These areas are double crosshatched to indicate Division 1. Figure 7 covers the remaining operation of Step 2, which is designed to test for Division 2. Based on the answers to these questions, it is determined that the outdoor process area should be classified Division 2 and these areas are single crosshatched accordingly. Note that the extent of the Division 1 and Division 2 areas is indefinite at this stage as indicated by the irregular perimeter of the crosshatching.

Step 3 is used to establish the extent of the classified areas and Figure 8 illustrates this operation. As instructed in Step 3, the clearances given in Figures 1, 2, and 3 have been applied with the result that the extent of the Division 2 areas is as indicated by the single crosshatching, while the double crosshatching indicates the extent of the Division 1 areas. Note that the sub station, which is made up of general-purpose equipment, is located outside the limits of the Division 2 areas, while the switch rack, which is made up of explosion-proof equipment, is located next to the control house, which is well within a Division 2 area.

Figure 9 is a continuation for purposes of illustrating Step 4. Since the flammable materials in this process which might create a hazard are hydrocarbons commonly encountered in refineries, the proper NEC atmospheric grouping is Group D. Thus by these four steps the area has been completely classified as to degree, extent, and group.

In conclusion, we believe RP-500 provides a sound and practical basis for accurately and consistently classifying hazardous areas in refineries. However, this is by no means the end of the road. It is expected that RP-500 will require revision periodically as experience is acquired in its use. Another problem that will always be with us regardless of how proficient we become in classifying areas is that of making sure an installation is put in as designed. Designs must be executed exactly and construction supervisors and inspectors must be given a better understanding of why this is important.

Another phase that needs attention is the lack of equipment designed for Division 2 locations, and the application of presently available materials and equipment not now accepted for Division 2 installations. An example of this is found in wiring methods. One of the greatest hazards in the use of conduits is the passage of gas through the conduit from a hazardous to a non-hazardous area, thereby creating a hazard in a supposedly safe location, and affording a means for a flash to be transmitted to the hazardous area. Even though seals are used, their effectiveness is often questionable. The use of mineral insulated and armoured cable, though not underwriters approved for hazardous area wiring, would eliminate this hazard.

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ACKNOWLEDGMENT

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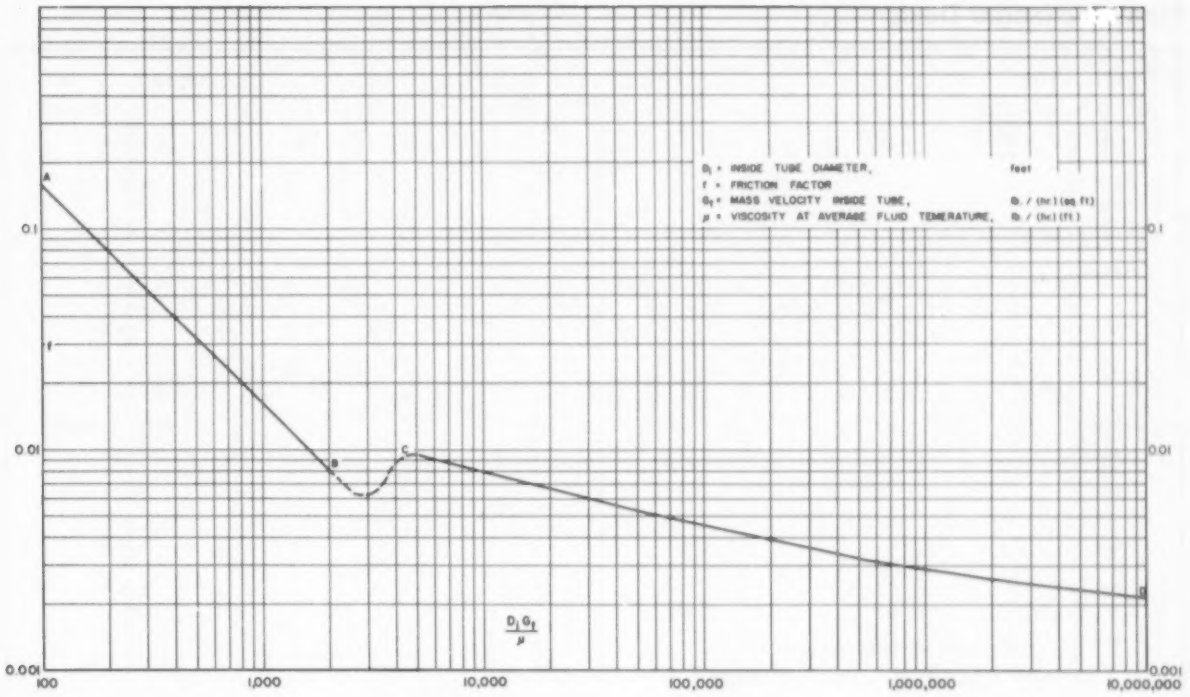


FIGURE 24—Friction factor for flow inside tubes.

Heat Exchanger Design

Part 1: Types and Arrangements
Part 2: Heat Transfer
Part 3: Fluid Flow and Thermal Design
Part 4: Mechanical Design

Daniel A. Donohue, Chemical Construction Corporation, New York

Pressure Drop—For the purpose of obtaining the highest attainable coefficients of heat transfer from the fluids flowing inside and outside the tubes it is necessary to arrange for fluid velocities which will fully utilize allowable pressure drops.

Pressure Drop Inside Tubes—The frictional pressure drop developed by fluids flowing through tubes or pipes is expressed by the relation:

$$\Delta p_t = \frac{2\,f\,L\,(G'_t)^2}{g D_i \rho} \qquad (30)$$

The friction factor, f, is a function of the reynolds number as shown in Figure 24.

Streamline Flow—When the Reynolds number is less than 2,100 streamline flow occurs and line AB of Figure 24 defines the relationship. The equation of this line is

$$f = \frac{16}{\frac{D_i G_t}{\mu}} \qquad (31)$$

Equation (31) is substituted in (30) and increased by 20 percent to allow for possible fouling inside the tubes

$$\Delta p'_t = \frac{6.55}{10^7} \quad \frac{w\,\mu'\,L}{(D'_i)^4 s.g.} \qquad (32)$$

where

D_i	= inside diameter,	feet
D'_i	= inside diameter,	inches
f	= friction factor	
g	= acceleration of gravity, 32.2 ft./(sec.) (sec.)	
G_t	= mass velocity inside tube,	lb./hr. (sq. ft.)
G'_t	= mass velocity inside tube,	lb./sec. (sq. ft.)
L	= length,	feet

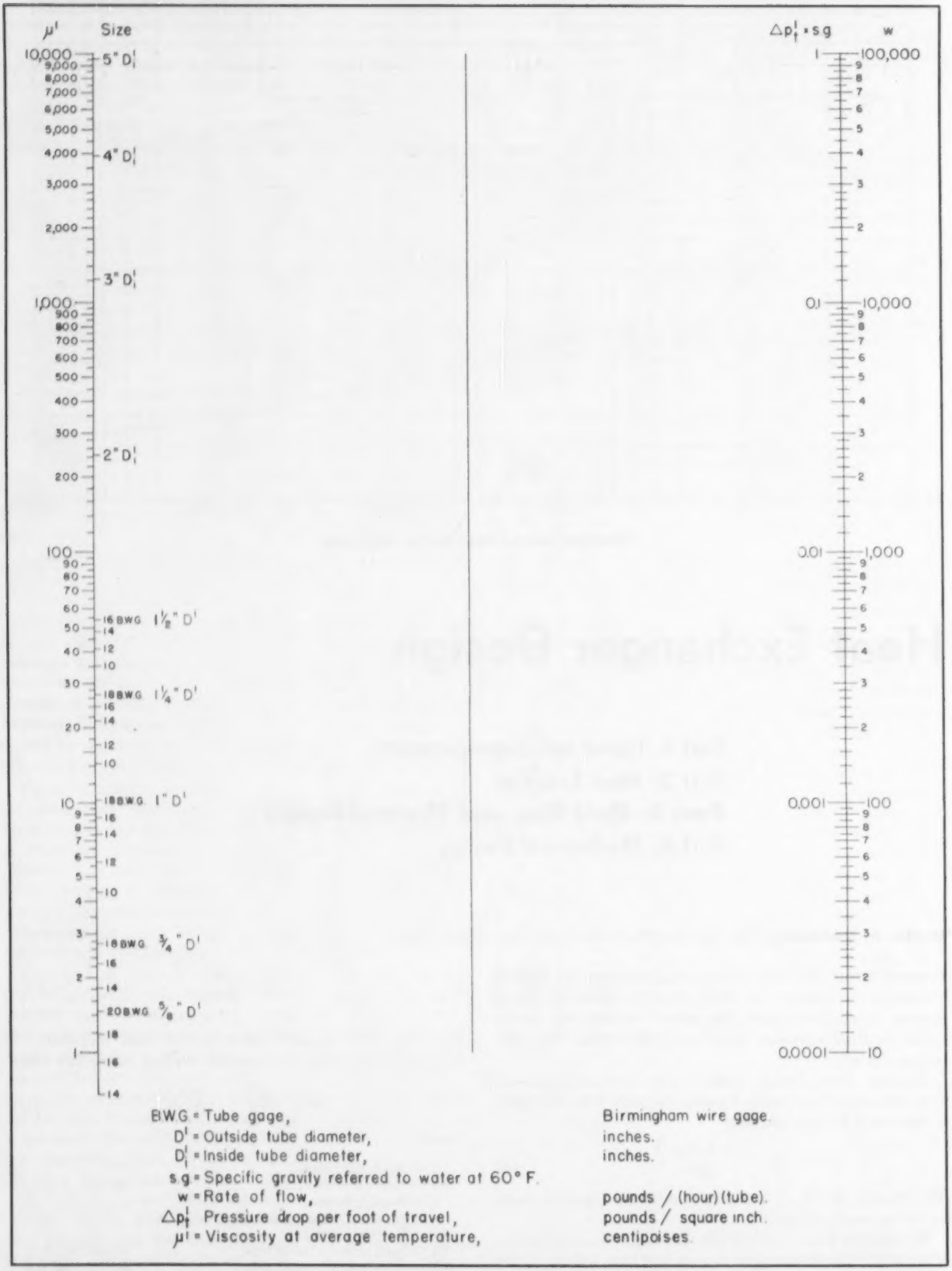


FIGURE 25—Pressure drop for fluids inside circular cross-sections, streamline flow ($N_{Re} < 2{,}100$).

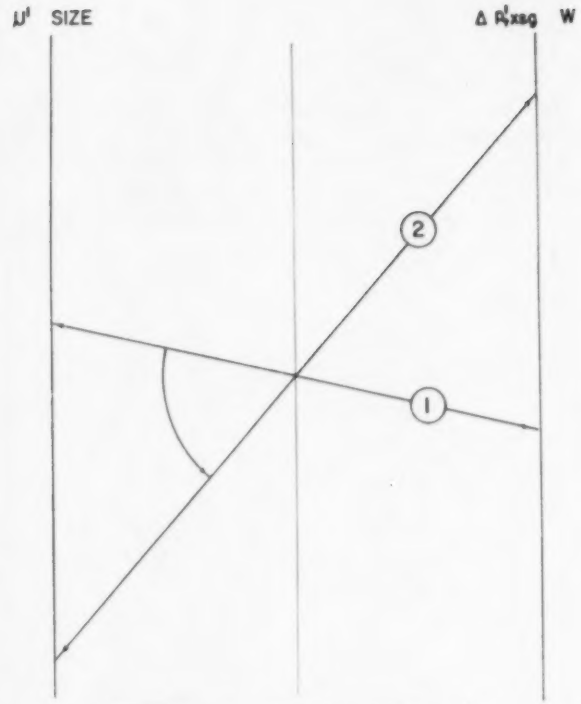


FIGURE 25A—Instructions for use of Figure 25.

DIRECTIONS FOR USE: Line 1: Connect values on w and μ' scales with straightedge. Line 2: Pivot straightedge about point of intersection of Line 1 with the uncalibrated line until it intersects the appropriate value on the tube-size scale. Result is read where Line 2 intersects the $\Delta p'_t$ x s.g. scale. EXAMPLE: Bunker C Fuel Oil flows through a ¾" O.D., 14 BWG steel tube at the rate of 416 lb./hr. The viscosity of this oil at average temperature is 190 centipoises and at the tube-wall temperature is 7 centipoises. The oil has a specific gravity of 0.91 at average temperature. 1—Connect w = 416 and μ' = 190 with Line 1. 2—Pivot Line 1 about its intercept on uncalibrated line until it intersects ¾" O.D., 14 BWG. 3—Read $\Delta p'_t$ x s.g. = 0.45. This value is divided by 0.91 to give 0.494 psi per foot of travel for the isothermal pressure drop. To take account of the viscosity gradient this isothermal value must be divided by 1.1 $(\mu/\mu_w)^{0.25}$ which equals 2.51. Therefore, the corrected pressure loss is 0.197 psi per foot of travel.

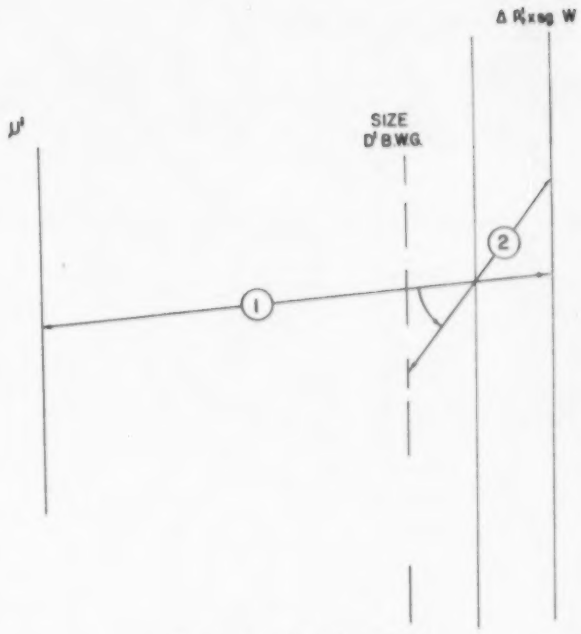
s.g.	= specific gravity referred to water at 60° F.	
w	= rate of flow,	lb./(hr.) (tube)
Δp_t	= pressure drop,	lb./sq. ft.
$\Delta p'_t$	= pressure drop,	lb./sq. in.
μ	= viscosity at average temperature,	lb./(hr.) (ft.)
μ'	= viscosity at average temperature,	centipoises
ρ	= density,	lb./cu. ft.

Figure 25 is an alignment chart which may be used to solve equation (32), and Figure 25A describes its use.

Turbulent Flow—When the Reynolds number for flow inside a tube exceeds 2,100 the flow is turbulent. Line CD of Figure 24 defines the relation between friction factor and Reynolds number for smooth tubes such as are always used in tubular heat exchangers. The equation of this line is

$$f = 0.0014 + \left(\frac{D_i G_t}{\mu}\right)^{-0.32} \qquad (33)$$

Within the range of Reynolds number from 5,000 to 10,000,000 the friction factor for smooth tubes may be represented within ±10 percent by the equation



(See next page for Figure 26.)

FIGURE 26A—Instructions for use of Figure 26.

DIRECTIONS FOR USE: Line 1: Connect w and μ' scales with straightedge. Line 2: Pivot straightedge about intersection of Line 1 with uncalibrated line until it intersects the appropriate value on the tube-size scale. Result is read where Line 2 intersects $\Delta p'_t$ x s.g. scale. EXAMPLE: Determine the pressure drop when 2,360 lb./hr. of water flow inside a ¾" O.D., 16 BWG admiralty tube at an average temperature of 60° F. 1—Connect w = 2,360 and t = 60° F. (for water) with Line 1. 2—Pivot Line 1 about its intercept on uncalibrated line until it intersects ¾" O.D., 16 BWG. 3—Read $\Delta p'_t$ x s.g. = 0.104 3. This reading is divided by the specific gravity, which is 1, to obtain 0.104 3 psi per foot of travel for the isothermal pressure drop.

$$f = \frac{0.048}{\left(\frac{D_i G_t}{\mu}\right)^{0.2}} \qquad (34)$$

Equation (34) is substituted in (30) and a safety factor of 20 percent, to allow for possible fouling inside the tubes, is added to yield

$$\Delta p'_t = \frac{8.57}{10^6} \; w^{1.8} \; \frac{L}{(D')^{4.8}} \; \frac{(\mu)^{0.2}}{s.g.} \qquad (35)$$

Figure 26 is an alignment chart for evaluating equation (35) and its use is described in Figure 26A.

The values read from Figures 25 and 26 are the product $\Delta p'_t \times$ s.g. and must be divided by the specific gravity of the fluid to obtain the isothermal pressure drop per foot of travel.

Viscosity Gradient—Pressure drop values obtained from Figures 25 and 26 are for isothermal flow in which the fluid temperature does not vary. To adjust for the effect of temperature gradient through the fluid the value for turbulent flow is divided by 1.02 $(\mu/\mu_w)^{0.14}$ and the value for streamline flow divided by 1.1 $(\mu/\mu_w)^{0.25}$.

Additional Pressure Losses—In addition to its path of flow inside the tubes the fluid flows through the channel nozzles, channel and floating-head cover, during which changes in velocity occur. In order to take account of

these enlargement and contraction losses a length equal to $6D'_t$ feet shall be added to the tube length in each pass; this is equivalent to 2¼ velocity heads per tube pass.

Shell Pressure Drop—

1. *Through Baffle Cutout*—The entire quantity of fluid flowing through the shell must pass through the openings of each baffle. The area open for flow is the area of the

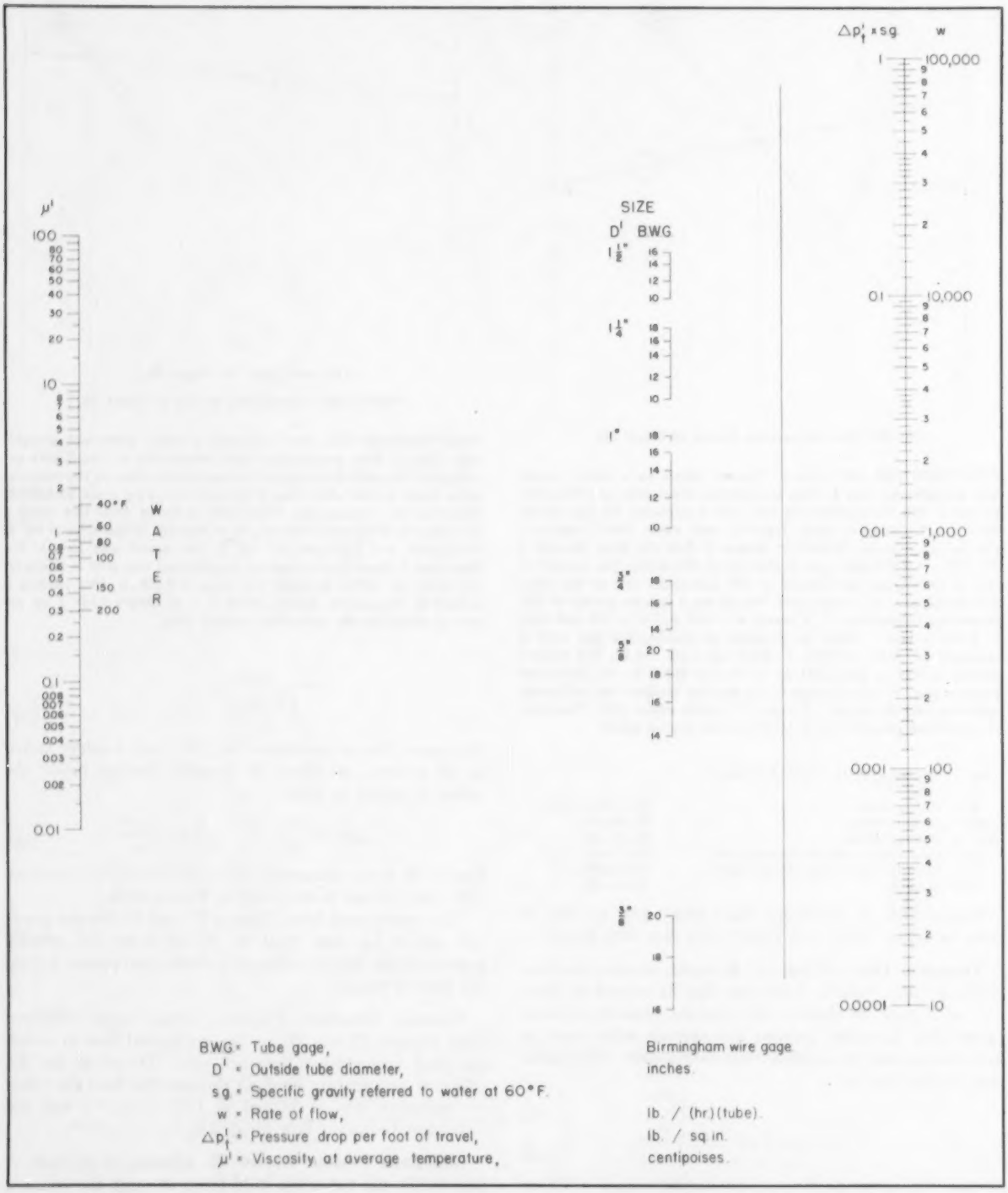
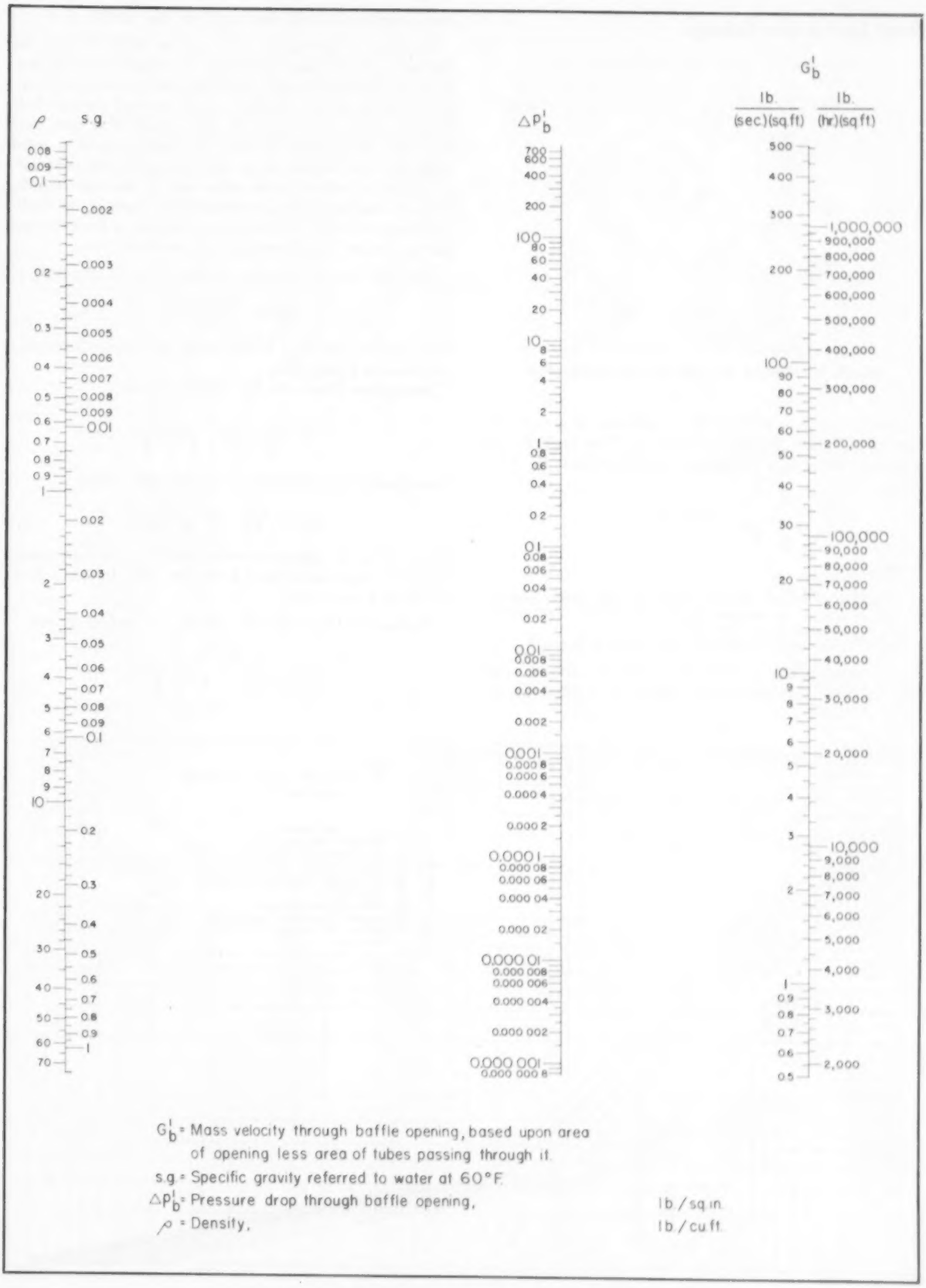


FIGURE 26—Pressure drop for fluids inside circular cross sections, turbulent flow ($N_{Re} > 2{,}100$).



G'_b = Mass velocity through baffle opening, based upon area of opening less area of tubes passing through it.

s.g. = Specific gravity referred to water at 60°F.

$\Delta p'_b$ = Pressure drop through baffle opening, lb./sq.in.

ρ = Density, lb./cu.ft.

FIGURE 27—Pressure drop for flow through baffle opening.

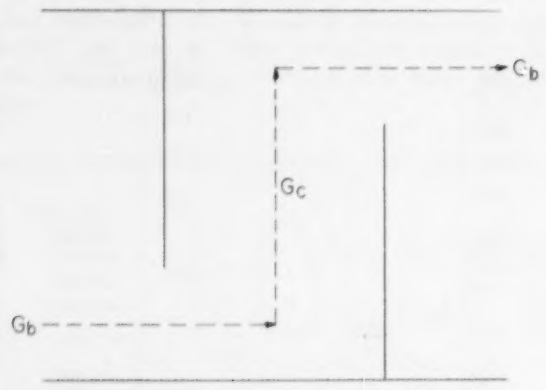


FIGURE 28—Idealized flow path of fluid through shell.

segmental baffle cutout less the cross-sectional area of the tubes which pass through this cutout. The pressure loss occurring through a segmental opening equals 0.7 of a velocity head.[6]

$$\Delta p'_b = \frac{3.76\ (G'_b)^2}{10^8\ s.g.} \qquad (36)$$

where

G'_b = mass velocity through baffle opening, based upon the area of the opening less the area of the tubes passing through it, lb./(sec.) (sq. ft.)
$\Delta p'_b$ = pressure drop through baffle opening, lb./sq. in.

Figure 27 is an alignment chart for the solution of equation (36). To use, connect the appropriate values on the two outer scales and read $\Delta p'_b$ on the middle scale.

2. *Across Tube Bank*—The path of flow through the baffled shell of a heat exchanger is complicated and sensitive to apparently minor structural differences. An idealized concept of how the flow could proceed through baffling is shown in Figure 28 from which it is seen that after the fluid passes through the baffle cutout it must cross the tube bundle to get the opening in the next baffle which is located at the other side of the tube bundle. The relation used for determining this part of the shell-side pressure drop is based upon that for a fluid flowing across a tube bank having a uniform flow area.

For this type of flow the pressure drop is expressed as

$$\Delta p_c = \frac{2\,f\,N\,(G'_c)^2}{g\,\rho} \qquad (37)$$

The friction factor, f, is a function of Reynolds number as shown in Figure 29.

Streamline Flow—In the viscous region

$$f = \frac{15}{\left(\frac{P-D}{D}\right)\left(\frac{DG_c}{\mu}\right)} \qquad (38)$$

Combination of equations (37) and (38) yields

$$\Delta p'_c = \frac{8.37}{10^5}\ \frac{N}{s.g.}\ \frac{G'_c\,\mu'}{P'-D'} \qquad (39)$$

Figure 30 is an alignment chart which has been prepared to permit rapid solution of Equation (39). Its use is illustrated in Figure 30A.

Turbulent Flow—In the region of turbulent flow

$$f = \frac{0.75}{\left(\frac{P-D}{D}\right)^{0.2}\left(\frac{DG_c}{\mu}\right)^{0.2}} \qquad (40)$$

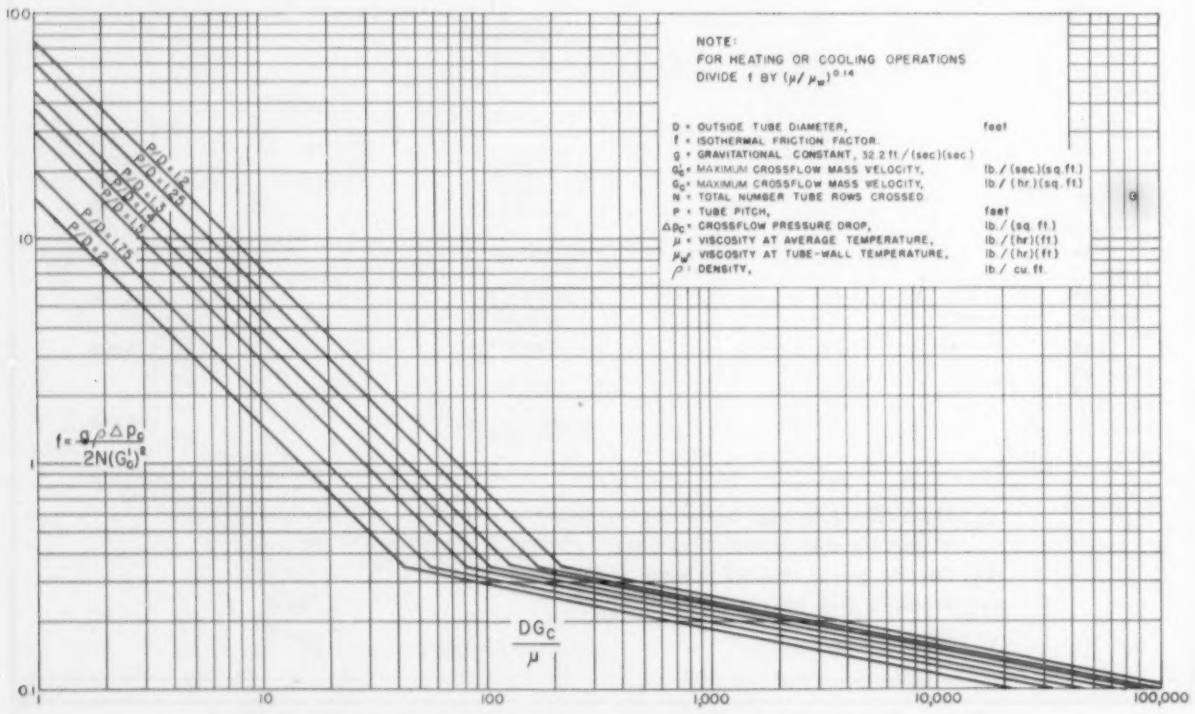


FIGURE 29—Isothermal friction factor for flow across tube banks.

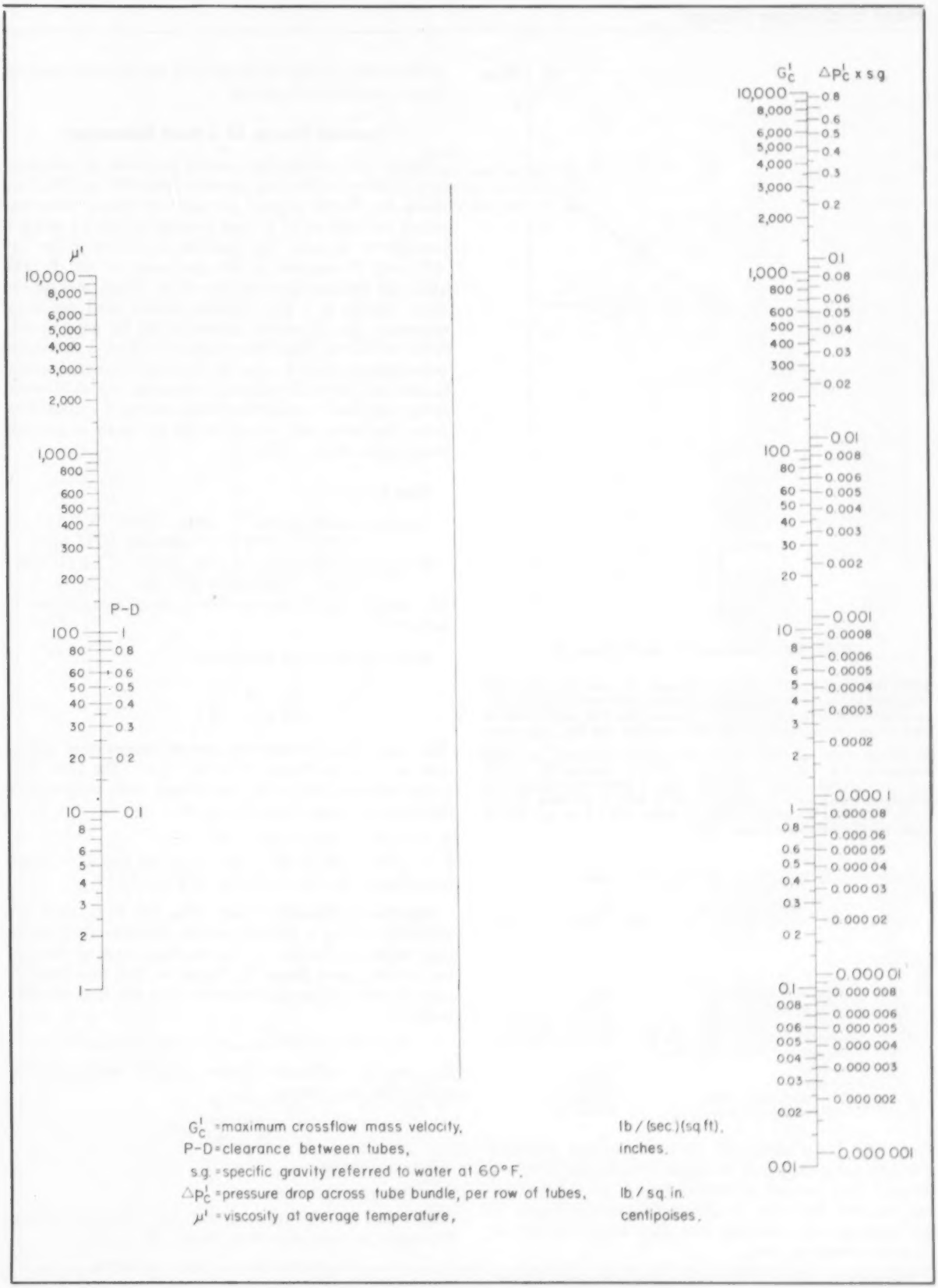


FIGURE 30—Pressure drop for isothermal streamline flow across tube bank.

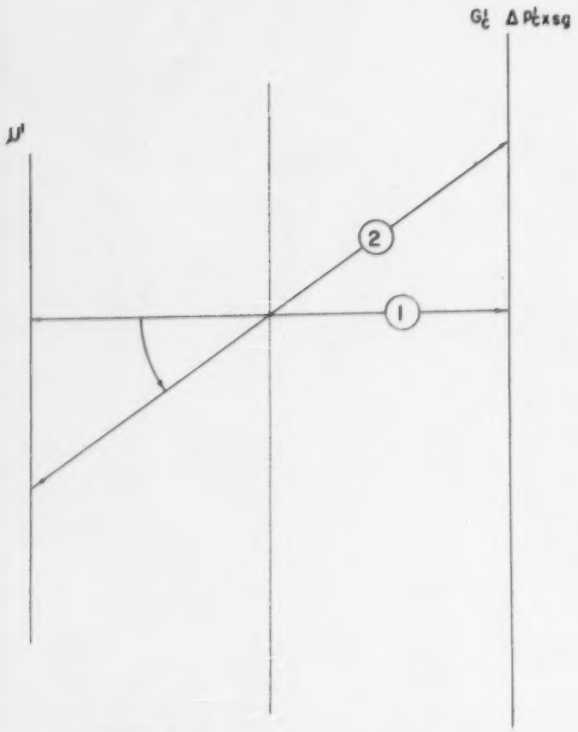


FIGURE 30A—Instructions for use of Figure 30.

DIRECTIONS FOR USE: Line 1: Connect G'_c and μ' scales with straightedge. Line 2: Pivot straightedge about point where Line 1 intersects the uncalibrated line until it intersects the P-D scale. Result is read where the right end of this line intersects the $\Delta p'_c$ x s.g. scale.

EXAMPLE: Find $\Delta p'_c$ when $G'_c = 56.1$ lb./(sec.) (sq. ft.), $\mu' = 444$ centipoises, P-D = 0.187 5" and s.g. = 0.97. 1—Connect $G'_c = 56.1$ and $\mu' = 444$ with Line 1. 2—Pivot Line 1 about its intercept on uncalibrated line until it intersects P-D = 0.187 5. 3—Read $\Delta p'_c = 0.111$. This value is divided by 0.97 to obtain 0.114 2 psi per foot of travel for the isothermal pressure drop.

Substitution of Equation (40) in (37) yields

$$\Delta p'_c = \frac{1.98}{10^6} (G'_c)^{1.8} \frac{(\mu')^{0.2}}{\text{s.g.}} \frac{N}{(P' - D')^{0.2}} \qquad (41)$$

where:

D	= Outside tube diameter,	feet
D'	= Outside tube diameter,	inches
G_c	= Maximum crossflow mass velocity,	lb./(hr.) (sq. ft.)
G'_c	= Maximum crossflow mass velocity,	lb./(sec.) (sq. ft.)
N	= Total number tube rows crossed	
P	= Tube pitch,	feet
P'	= Tube pitch,	inches
Δp_c	= Crossflow pressure drop,	lb./sq. ft.
$\Delta p'_c$	= Crossflow pressure drop,	lb./sq. in.

Figure 31 is an alignment chart for solving Equation (41). Its use is explained in Figure 31A. Figure 31 should be used first because turbulent flow is most frequently encountered. However, if viscous flow occurs Figure 31 will indicate this condition and then Figure 30 for viscous flow must be used.

Viscosity Gradient—The values obtained from Figures 30 and 31 are for isothermal flow. To adjust for viscosity gradient they should be divided by the viscosity gradient factor previously mentioned.

Thermal Design of a Heat Exchanger

Duty—To cool 54,104 pounds per hour of debutanized gasoline at 190 psig pressure from 190 to 100 F. by means of 175,000 pounds per hour of cooling water entering the unit at 85 F. and leaving at 100 F., under a pressure of 45 psig. The gasoline has a gravity of 52° API and its viscosity is 0.6 centipoise at 100 F. The allowable pressure drop on the oil is 10 psi, and on the water stream is 5 psi. Fouling factors used are those customary for oil refinery service, 0.001 for gasoline and 0.003 for water. Since the gasoline is clean a triangular tube spacing, ¾-inch tubes on $^{15}/_{16}$-inch triangular pitch, is used and the baffle openings are at the top and bottom of the alternately spaced baffles producing a vertical flow across the tubes and normal to the 60° angle of the diamond tube pitch.

Heat Load—

Gasoline: 54,104 lb./hr. × (190 — 100)° × 0.54 BTU/(lb.)(°F.) = 2,630,000 BTU/hr.

Water: 175,000 lb./hr. × (100 — 85)° × 1 BTU/(lb.)(°F.) = 2,630,000 BTU/hr.

The specific heat of the gasoline is found from Figure 15 to be 0.54.

Mean Temperature Difference—

190	→	100
100	←	85
90	41.8°	15

The logarithmic counterflow mean temperature difference is found in Figure 16 to be 41.8°. The correction factor to be applied to the logarithmic mean temperature difference is found from Figure 18.

R = (190 — 100)/(100 — 85) = 6,

P = (100 — 85)/(190 — 85) = 0.143 and F = 0.815 from Figure 18. The corrected MTD is 34.1°.

Selection of Trial-Size Unit—The unit to be tried is a #20-192 having a 20-inch outside diameter shell and a tube length of 16 feet. A cross-sectional view of this unit has already been shown in Figure 3. The unit has 292 tubes of ¾-inch outside diameter and the heat transfer surface is

$$A = 292 \times 0.1963 \text{ sq. ft./ft.} \times 16 \text{ ft.} = 918 \text{ sq. ft.}$$

The over-all coefficient of heat transfer which must be attained in this unit is

$$U = \frac{2{,}630{,}000}{918 \times 34.1} = 84$$

Pressure Drop—

1—Tube Side.

This unit has 292 tubes ¾-inch OD 16 BWG, 2 pass. The chart for turbulent flow, Figure 26 is used.

$$w = 175{,}000/146 = 1{,}198 \quad t = 93° \text{ F.}$$

From Figure 26 $\Delta p'_t \times$ s.g. = 0.027 and $\Delta p'_t = 0.027$

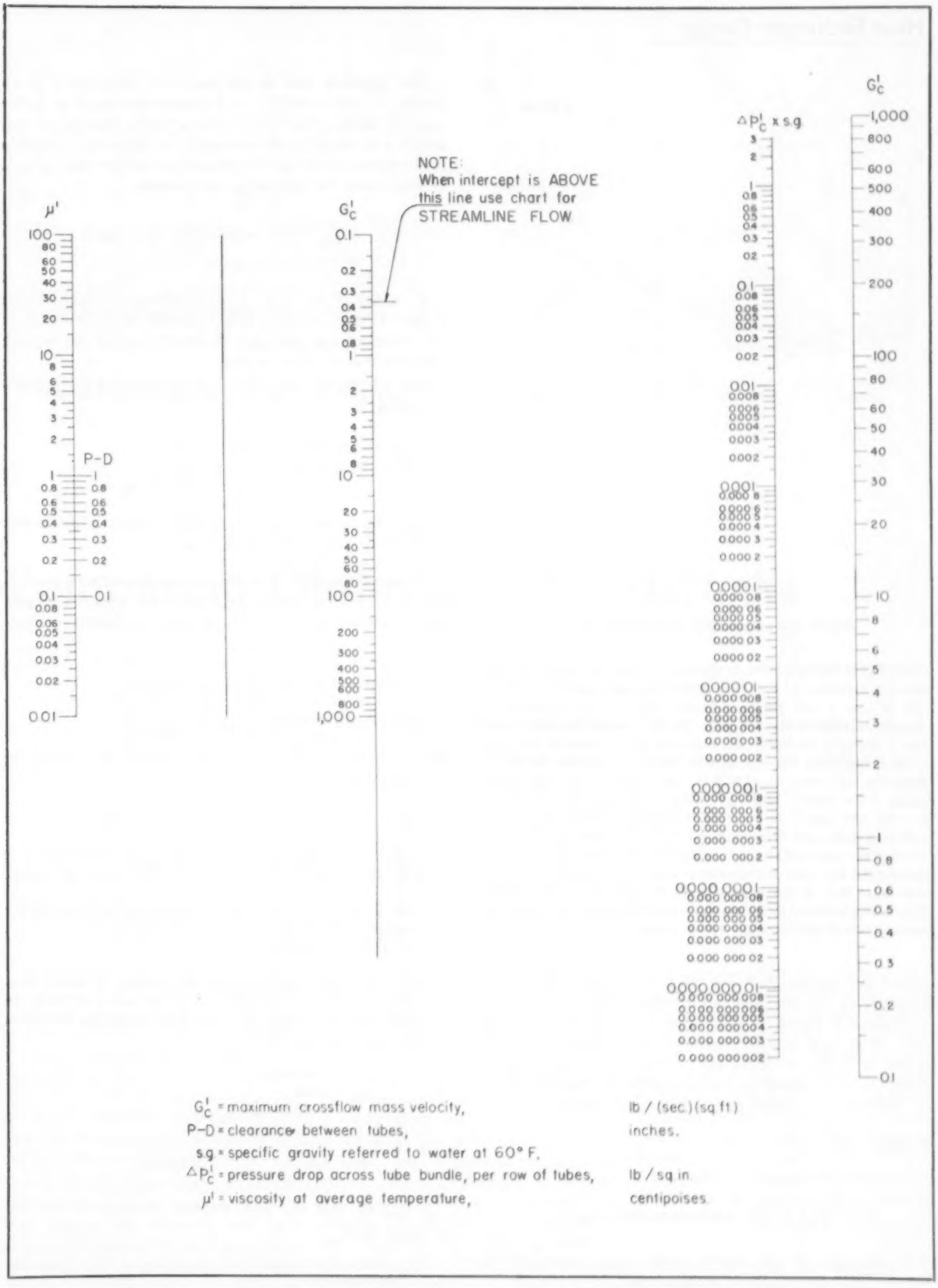

NOTE:
When intercept is ABOVE this line use chart for STREAMLINE FLOW
μ'
P-D
G'c
ΔP'c x s.g.
G'c
G'c = maximum crossflow mass velocity, lb / (sec.)(sq ft)
P-D = clearance between tubes, inches.
s.g. = specific gravity referred to water at 60° F.
ΔP'c = pressure drop across tube bundle, per row of tubes, lb / sq in.
μ' = viscosity at average temperature, centipoises

FIGURE 31—Pressure drop for isothermal turbulent flow across tube bank.

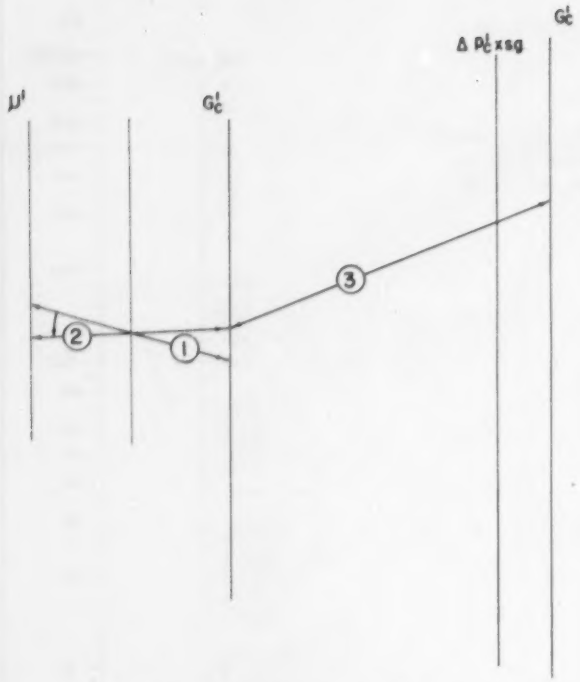


FIGURE 31A—Instructions for use of Figure 31.

DIRECTIONS FOR USE: Line 1: Connect μ' scale and middle G'_c scale with a straightedge. Line 2: Pivot straightedge about point of intersection of Line 1 with the uncalibrated scale until it intersects the appropriate value on the P-D scale. Line 3: Connect the point where Line 2 intersects the middle G'_c scale with the G'_c scale at the right. Result is read where this line intersects the $\Delta p'_c$ x s.g. scale. EXAMPLE: Determine $\Delta p'_c$ when $G'_c = 96.2$ lb./(sec.) (sq. ft.), $\mu' = 0.5$ centipoises, P-D = 0.187 5" and s.g. = 0.74. 1—Connect $G'_c = 96.2$ and $\mu' = 0.5$ with Line 1. 2—Pivot Line 1 about its intercept on the uncalibrated scale until it intersects P-D = 0.187 5" and note the point at which the right end of this line intersects the middle G'_c scale. 3—Connect this last point, the intercept of Line 2 on the middle G'_c scale, with $G'_c = 96.2$ on the scale at right. 4—Read $\Delta p'_c$ x s.g. = 0.009. This reading is divided by the specific gravity 0.74 to give the isothermal pressure drop of 0.012 2 psi per foot of travel.

pound per square inch per foot of travel. The tube length is 16 feet per pass and for additional entrance and exit losses a length of 6 D'_t feet = $6 \times 0.62 = 3.72$ feet is added to each tube pass. Total length is $2\,(16 + 3.72) = 39.44$ feet. Total tube side pressure drop = 0.027 pound per square inch per foot of travel $\times$ 39.44 feet = 1.066 pound per square inch.

2—Shell Side.

a—Through Cutout.

$$G_b = \frac{54{,}104 \text{ lb./hr.}}{0.24 \text{ sq. ft.}} = 225{,}000 \text{ lb./(hr.) (sq. ft.)}$$

From Figure 27 $\Delta p'_b$ the pressure drop per baffle is found to be 0.02 pound per square inch.

b—Across Tube Bundle.

The crossflow area at the horizontal diameter is 19.25 inches — $(19 \times 0.75) = 5$ inches per inch of baffle spacing. After trial and error a baffle spacing of 4½ inches was found to be necessary to utilize the available shell pressure drop of 10 pounds per square inch as will be seen from the following calculations.

$$G_c = \frac{54{,}105 \text{ lb./hr.}}{0.1561 \text{ sq. ft.}} = 346{,}000 \text{ lb./(hr.) (sq. ft.)}$$
$$G'_c = 96.2 \text{ lb./(sec.) (sq. ft.)}$$

$\mu' = 0.5$, P — D = 0.1875 and s.g. = 0.74. From Figure 31 $\Delta p'_c \times$ s.g. = 0.009. Divide by 0.74 which is the value of s.g. and $\Delta p'_c = 0.0122$ pound per square inch per row of tubes crossed.

The number of tube rows crossed is 16 and the number of baffles 38.

$$\Delta p'_c = 0.0122 \times 16 \times 39 = 7.62$$
$$\Delta p'_t = 0.02 \times 38 = 0.76$$
$$8.38 \text{ lb./sq. in.}$$

A safety factor of 20 percent is added which increases this value to 10 pounds per square inch.

Over-All Coefficient of Heat Transfer—The five component coefficients of heat transfer are to be evaluated and combined to yield the over-all coefficient of heat transfer.

h_o The value of h_o is obtained from Figure 23.
$G'_e = (G'_c G'_b)^{1/2} = (96.2 \times 62.5)^{1/2} = 77.5$
$\mu = 0.5$ 52° API
From Figure 23. $h_o = 184$ $r_o = 0.005\,44$

h_{do}
For gasoline $r_{do} = 0.001$

h_m
$$D_m = \frac{D - D_t}{\log_e (D/D_t)} = \frac{0.75 - 0.62}{\log_e (0.75/0.62)} = 0.682$$
$$r_m\left(\frac{D}{D_m}\right) = \frac{t}{k}\left(\frac{D}{D_m}\right) = \frac{0.005\,42}{64}\left(\frac{0.75}{0.682}\right) = 0.000\,093\,3$$

h_{di}
For water $r_{di} = 0.003$. To convert to external tube surface multiply by D/D_t which from Table 15 is 1.21
$r_{di}\,(D/D_t) = 0.003\,63$

h_i
h_i, referred to the external tube surface, is found from Figure 21. For w = 1,198, t = 93° F. and a ¾" O.D. 16 BWG tube $h_i = 606$ $r_i = 0.001\,65$ Combining resistances by use of equation (19)

r_o — 0.005 44
r_{do} — 0.001
$r_m\,(D/D_m)$ — 0.000 093 3
$r_{di}\,(D/D_t)$ — 0.003 63
$r_i\,(D/D_t)$ — 0.001 65
R — 0.011 81 $\qquad U = 84.6$

It is seen that the unit selected is adequate for the specified duty.

A complete list of the literature cited was published with Part 1, Page 100, August, 1955, REFINER.

End of Part 3. Part 4 (conclusion) will appear in an early issue.

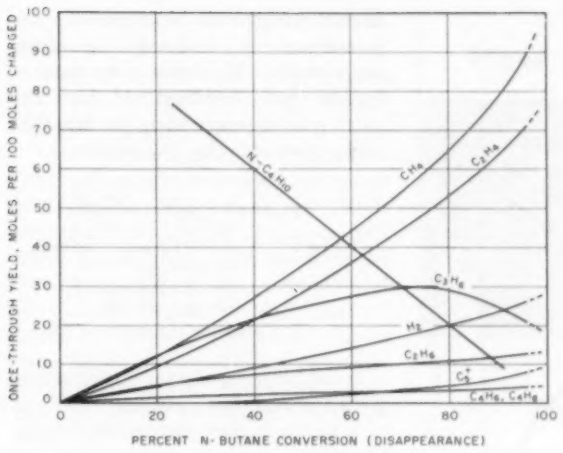


FIGURE 1—Once-through yields from n-butane pyrolysis for tubular units with exit conditions of 1350-1400 F. and 0-20 psig.

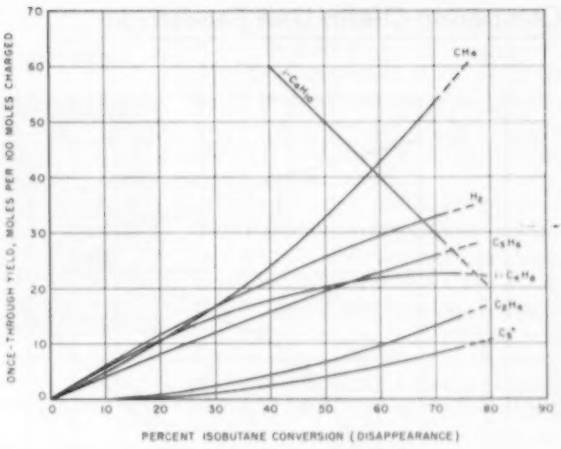


FIGURE 2—Once-through yields from isobutane pyrolysis for tubular units with exit conditions of 1300-1400 F. and 0-20 psig.

Comparing Olefin Unit Feedstocks

Cost comparison shows that butane may soon be a strong competitor of propane as major light hydrocarbon feedstock for ethylene and propylene production.

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University of Texas,
Austin, Texas

SOMEDAY, perhaps in the not too distant future, the prices of butane and propane may be such that it will be advantageous to use butane instead of propane as a charge stock for ethylene and propylene production. Even current average prices for these raw materials indicate an advantage for butane if the demand for high grade propylene is sufficient.

The primary products from the commercial cracking of both propane and butane are ethylene and propylene. The purification of propylene obtained from propane cracking, however, requires the separation of propylene from propane. This step is not necessary in the purification of butane cracking products since no propane is produced in butane cracking, and pure propylene is obtained direct from the depropanizer.

A further factor which indicates an advantage for butane charge stock is the greater ratio of propylene to ethylene in the products. This may become more important as the economic picture continues to change and the demand for propylene increases. The current yearly demands are roughly 2.7 billion pounds of ethylene and 1.3 billion pounds of propylene.[4]

The several possible advantages in the use of butane feed certainly emphasize the necessity for continuous review of current methods for producing ethylene and propylene. This article is presented as an aid to such review. It is restricted to the production of ethylene and propylene by cracking of butanes and a comparison with cracking of propane. Pyrolysis yields and practice for ethane and propane charge materials have been amply discussed by Kinney and Crowley[6] and Schutt.[11]

Raw Material Situation—Butanes are widely used as LPG fuel, as raw materials for such refinery processes

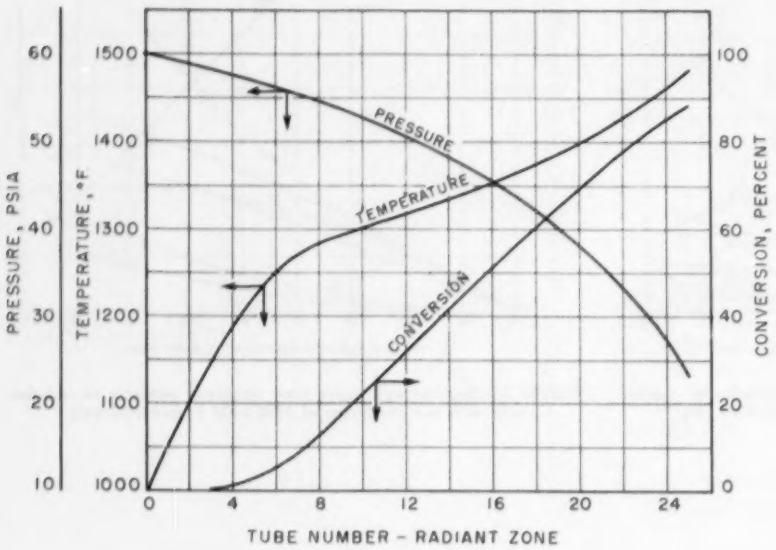

FIGURE 3—Coil analysis curves for n-butane pyrolysis. Basis: 7000 lb./hr. charge, single pass, 4" ID tubes, 24'-0" long.

as isomerization and alkylation, as source materials in the manufacture of synthetic rubber, and for direct blending with gasoline. Because of this use pattern, the price of butanes shows fluctuation with business conditions and time of year. The branched structure of isobutane gives it a premium price but, as will be shown later, it is not particularly suitable for ethylene-propylene manufacture. The price of n-butane may range from two to seven cents per gallon, but in the Gulf Coast area a steady year-round consumer can purchase it for about 4.0 cents per gallon. This may be compared with a propane price on the same basis of about 3.5 cents per gallon. While such figures are, of course, transitory, the important point is that n-butane is about 0.5 cents per gallon more expensive than propane, the latter being a commonly-used raw material for the manufacture of ethylene and propylene.

n-Butane Pyrolysis—The discussion here will be based on the use of fired tubular heaters in commercial practice, although other devices for obtaining the necessary time-temperature relationships may be used. An example of this is the recent paper of Kilpatrick et al,[5] in which the pyrolysis of n-butane in a pebble heater is described.

The kinetics of the thermal decomposition of n-butane have been studied by several investigators. The decomposition proceeds as a chain reaction which can be expressed approximately as a first order homogeneous reaction. The laboratory data of Steacie and Puddington[12] give the most reliable expression for the first order reaction velocity constant.

$$k = 10^{12.7} (\exp) -\frac{58{,}700}{RT}$$

where k = first-order reaction velocity constant, sec^{-1}
R = universal gas constant, cal/gm-mole/°K
T = absolute temperature, °K.

It has been found that this equation gives low and thus conservative values of k in the higher conversion ranges. Calculated coil-exit temperatures are about 50 F. higher than observed. A slight adjustment of the activation energy of 58,700 cal per gm-mole may be used to allow for secondary reactions.

Although n-butane decomposes through the formation of free radical chains, the overall primary decomposition reactions have been found to be:

$$n\text{-}C_4H_{10} \rightarrow CH_4 + C_3H_6 \quad (1)$$
$$n\text{-}C_4H_{10} \rightarrow C_2H_6 + C_2H_4 \quad (2)$$
$$n\text{-}C_4H_{10} \rightarrow H_2 + n\text{-}C_4H_8 \quad (3)$$
$$n\text{-}C_4H_{10} \rightarrow H_2 + 2C_2H_4 \quad (4)$$

By extrapolating ultimate-yield data to zero conversion, the relative distribution of these reactions may be found. The values of different observ-

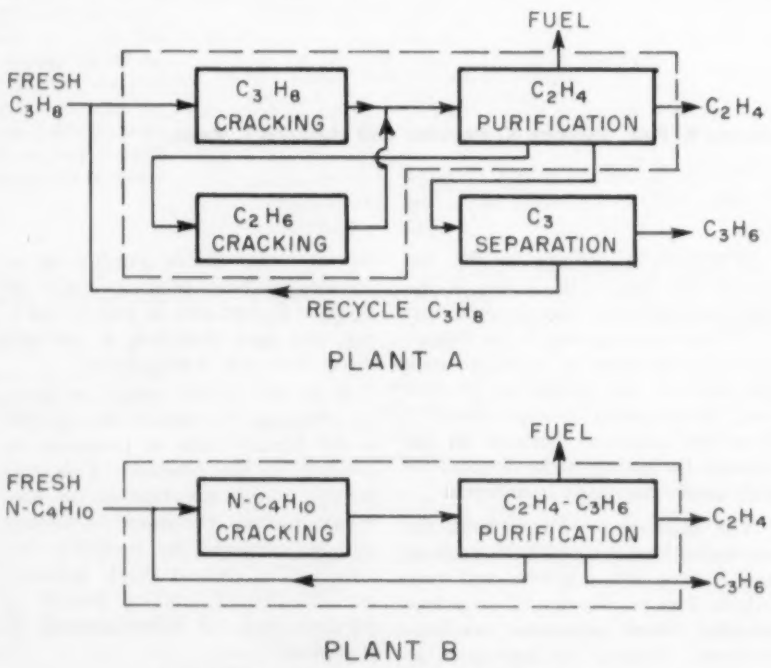

FIGURE 4—Block diagrams for Plants A and B.

ers are in disagreement probably because of differences in experimental and analytical methods. The evidence is convincing, however, that reactions (1) and (2) predominate.

Once-through yields of products from n-butane pyrolysis are presented in Figure 1. The curves have been smoothed from data of various origins, but in general have been based on the flow data of Neuhaus and Marek,[8] of Schultze and Weller[10] and of Egloff, Thomas, and Linn.[2] These data have been especially useful in establishing the maximum once-through yield of propylene. The yields apply to coil outlet temperatures of 1350 to 1400 F. and pressures in the vicinity of one atmosphere.

The absence of propane in the pyrolysis product is noteworthy. Thus, the C_3 fraction consists of pure propylene, as long as no propane is present in the charge stock.

Some heavy materials are formed in the decomposition process. These consist of 1-2 weight percent heavy ends boiling above 350 F., and a highly aromatic fraction denoted as C_5+ on the yield curves. This aromatic fraction has an average molecular weight of 75-80.

Isobutane Pyrolysis — The conditions for cracking isobutane are similar to those for n-butane. The initial decomposition is limited to two reactions, however:

$$i\text{-}C_4H_{10} \rightarrow CH_4 + C_3H_6 \quad (1)$$
$$i\text{-}C_4H_{10} \rightarrow H_2 + i\text{-}C_4H_8 \quad (2)$$

Reaction (2) appears to predominate slightly. It will be noted that ethylene is absent as a primary decomposition product. In general, the yield of ethylene from secondary reactions is also low. Isobutane is therefore, undesirable for combined ethylene-propylene production.

The kinetic data of Steacie and Puddington[12] are reliable for the 0-50 percent conversion range:

$$k = 10^{13.9}\,(\exp) -\frac{63{,}500}{RT}$$

where k = first-order reaction velocity constant, sec^{-1}
R = universal gas constant, cal/gm-mole/°K
T = absolute temperature, °K.

Results of commercial isobutane pyrolysis are not available to the authors, but it is expected that the above equation would give slightly conservative results at higher conversions. Arnold[1] reports commercial data from isobutane pyrolysis in the 20-30 percent range and suggests an activation energy of 62,560 cal per gm-mole instead of the value of 63,500 shown above.

Once-through yields of products from isobutane pyrolysis are presented in Figure 2. The curves are primarily based on the laboratory data of Marek and Neuhaus[7] and Schultze and Weller,[10] covering the 0-70 percent conversion range. These curves represent, with fairly good agreement, the commercial data reported by Arnold.[1] Since the yield of ethylene from isobutane is low, and since isobutane is more costly than n-butane, the remainder of this paper will be concerned with n-butane pyrolysis.

Reactor Design and Operation—In order to illustrate the economics of the commercial pyrolysis, or "cracking" of n-butane, a typical coil design calculation has been made according to the method outlined by Fair and Rase.[3] The design is based on charging 7000 pounds per hour of n-butane to a fired coil comprising 4.50″ (o.d.) × 0.250″ wall tubes arranged in a continuous pass of 24-foot straight lengths. The differential heat of cracking is essentially constant at 42,000 Btu per pound-mole n-butane converted. The charge is preheated separately to 1000 F. and in the radiant zone receives heat at 10,000 Btu per hour-foot^2 outside tube surface. The coil-analysis curves are shown in Figure 3.

In the example design which employed the uncorrected data of Steacie and Puddington,[12] it will be noted that the gas temperature reaches 1460 F. at 85 percent conversion. Observed temperatures for the same operating conditions are about 1400 F.

The operation of a reactor of this design is straight-forward and quite similar to that for ethane and propane reactors. The temperature conditions for butanes are somewhat milder, which leads to longer tube life. Periodic decoking is required, and this is influenced by the inclusion of a small amount (e.g., 5-10 percent) of steam in the charge. Although 55 percent and 80 percent are the usual maximum practicable conversions for ethane and propane, respectively, 90-95 percent conversions may be attained with n-butane.

Product Purification—The effluent

Meet the Authors

Perkins Fair Rase

THOMAS K. PERKINS is studying for his doctor's degree in chemical engineering at the University of Texas. Holder of both a bachelor and master's degree from Texas A&M College, he has devoted his doctoral research to the kinetics of olefin hydrogenation. He spent one summer with The Dow Chemical Company at Freeport, Texas.

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JAMES R. FAIR, JR., now a process design engineer with Shell Development Company at Emeryville, Calif., recently completed his Ph.D. at the University of Texas, where he held a grant as an Humble Oil & Refining Company research fellow while working on this article. During his previous year of doctoral study at the university he was a Gulf Oil Corporation research fellow. A graduate of Georgia Institute of Technology and holder of a master's degree from the University of Michigan, Dr. Fair formerly was a chemical engineer with Monsanto Chemical Company for more than ten years.

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HOWARD F. RASE is an assistant professor of chemical engineering at the University of Texas, where he received his first degree in 1942. A former chemical engineer for The Dow Chemical Company and later a project engineer with Foster Wheeler Corporation, he returned to school in 1950, receiving his master's degree at the University of Michigan and completing his Ph.D. there in 1952. He and Dr. Fair are co-authors of an article appearing in the PETROLEUM REFINER for July, 1954.

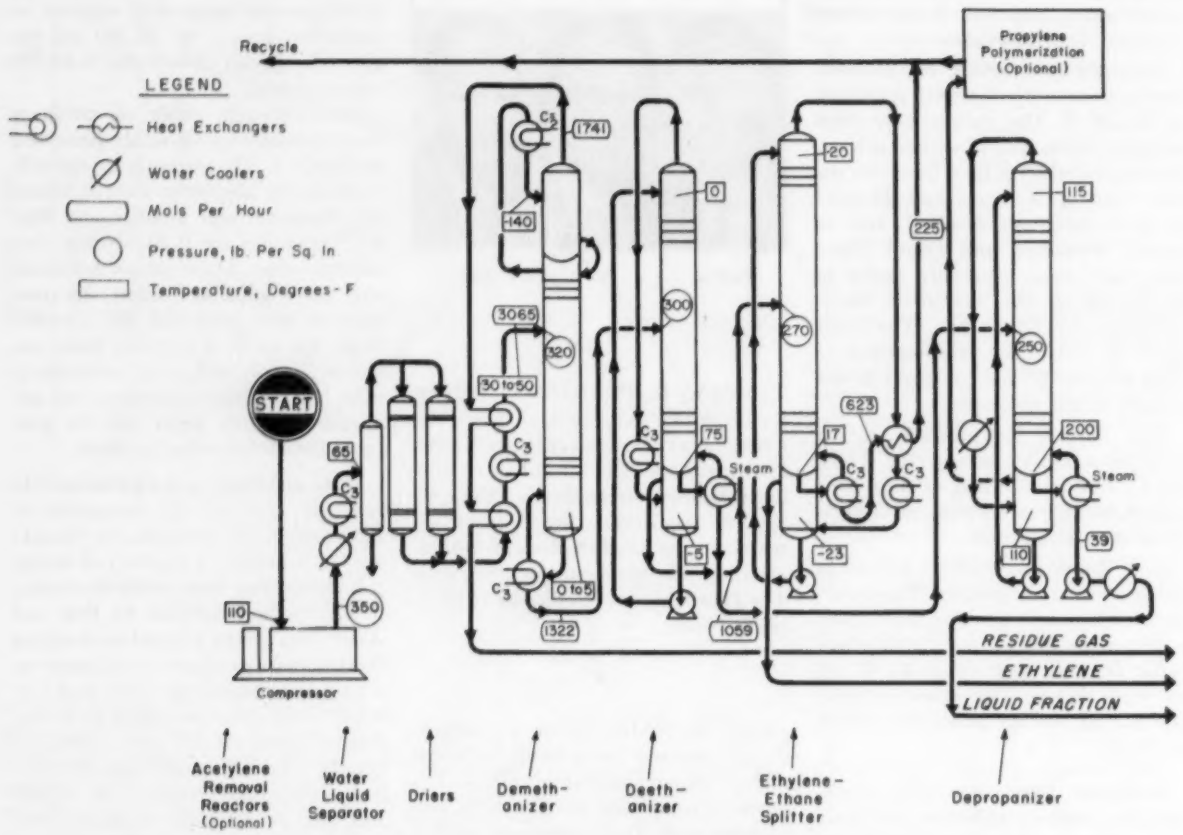

FIGURE 5—Ethylene purification flowsheet.

gases from n-butane pyrolysis may be separated and purified by conventional methods employed in ethane-propane pyrolysis. Because of the absence of propane, the purification of propylene is greatly simplified. The methods include low-temperature straight fractionation, low-temperature absorption-fractionation and hypersorption. Since the production of ethane is small, and since ethane pyrolysis conditions are different than those for n-butane, it is not generally economical to recycle this material. The C_4 fraction may either be recycled or sold for its content of unsaturated materials.

Economics—The economics of light olefin manufacture are complex, and depend on more factors than can be treated adequately here. Volumes of private industrial reports are required to weigh the economics even for one specific location. Thus, this discussion will be limited to one situation, and that one on a general basis.

Two plants will be compared. They are in the primary business of producing 75,000,000 pounds per year of ethylene, and in the secondary business of producing approximately 8,000,000 gallons per year of 95 + mole percent propylene. Plant A will be based on commercial propane (95 percent) as a raw material, with product ethane being recycled to a separate reactor for additional ethylene production. Plant B will be based on 95 percent n-butane (with no propane impurity) as a raw material, with product ethane being discharged for fuel credit. The plants are represented by the block diagrams of Figure 4. It will be noted that Plant A requires separate propane-propylene separation facilities.

The dash-enclosed purification sections of Plants A and B (Figure 4) are low-temperature straight fractionation units such as described by Pratt and Foskett.[9] The flow diagram, Figure 5, shows the processing scheme. Material balances applying to this section are presented in Tables 1 and 2. The over-all plant yields, in lbs./100 lbs. of fresh charge (including impurities), are:

	Plant A (Propane)	Plant B (n-Butane)
Ethylene	38.2	32.8
Propylene	15.4	20.0

These yields are based on 55 percent ethane conversion, 80 percent propane conversion, and 90 percent n-butane conversion.

If Plants A and B produce ethylene and propylene *at equivalent transfer* prices, then the processing cost for separating the C_3 fraction in Plant A must balance the increased raw material cost for Plant B. This assumes that the direct and indirect conversion costs, excluding C_3 separation, for the two plants are equal. This is not a bad assumption, since the product purification problems are quite similar

as is evidenced from the material balances in Tables 1 and 2.

The development of the economics comparing Plants A and B is presented in Table 3. It will be noted that the additional raw material cost for the butane-based plant is $260,000 per year. This is balanced by the return on the approximately $1 Million investment required for the separation of propylene from propane in Plant A. Thus, the additional manufacturing costs for the separation represent a debit against the propane process. These costs are estimated to be 2.5 cents per gallon for 90 percent recovery of 95 percent pure propylene.

The cost comparison is based on the following reasoning:

(a) Charge the C_3 separation unit of Plant A for its raw material propylene. Conservatively, this charge would be 3.5 cents per gallon of contained and recoverable propylene.

1. Raw material charge to propylene for Plant A $(7{,}000{,}000)\ (0.035) = \$245{,}000$.

2. Raw material charge to ethylene for Plant A $\$1{,}630{,}000 - \$245{,}000 = \$1{,}385{,}000$.

(b) Cost of propylene for Plant A:

Raw material cost + operating cost + return on investment $= 0.245 + 0.180 + 0.250 = \$0.675$ Mm annually or

$$\frac{(675{,}000)\ (100)}{7{,}000{,}000} = 9.65 \text{ cents per gallon.}$$

(c) Raw material charge to ethylene for Plant B will be the same as for Plant A. Each plant produces the same amount of ethylene and the conversion and separation costs for the ethylene should be nearly equivalent.

(d) Cost of propylene for Plant B:

Total raw material cost minus charge to ethylene $\$1{,}890{,}000 - \$1{,}385{,}000 = \$505{,}000$ $\$0.505$ Mm annually or,

$$\frac{(505{,}000)\ (100)}{10{,}310{,}000} = 4.9 \text{ cents per gallon.}$$

In addition to the favorable economics for butane cracking given in Table 3, it should be noted that the butane-plant produces over 3 million gallons more propylene annually than does the propane process. If this additional material is not needed, it can be recycled to the pyrolysis step to enhance the over-all yield of ethylene, i.e., to reduce the amount of fresh butane required.

Order-of-magnitude figures have been presented here because each specific case will be governed by particular conditions which cannot be conveniently generalized. It is felt, however, that the advantages of n-butane cracking are very real and worthy of consideration when both high-purity ethylene and high-purity propylene are desired.

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TABLE 3

Comparison of Ethylene-Propylene Production from Propane and n-Butane

PLANT	A	B
Charge Stock	Propane	n-Butane
Conversion, percent	80	90
Overall Plant Yld., Wt.-Percent		
Ethylene	38.2	32.8
Propylene	15.4	20.0
Charge Stock Req'd., Mm Gallon/Year	46.7	47.2
Charge Stock Cost		
Cents/gallon	3.5	4.0
$MM/year	1.63	1.89
Propylene Production, Mm Gallon/Year	7.00	10.31
Raw Material Charge to Propylene, $Mm	0.245	0.505
Propylene Separation Unit		
Total Capital*, $Mm	1.00	.....
Operating Cost		
Cents/Gallon	2.5	.....
$MM/Year	0.18	.....
Return on Investment†, $Mm/Year	0.25	.....
Cost of Propylene		
$Mm/Year	0.675	0.505
Cents/Gallon	9.65	4.9

* Including non-manufacturing capital.
† Based on four-year payout (before taxes).

TABLE 1

Material Balance for Ethylene-Propylene—Plant Based on Propane (Plant A)

Basis: 75 Mm Pounds Per Year Ethylene, 8000 Hours Per Year, 80 Percent C_3H_8 Conversion

Flows in pound moles per hour

COMPONENT	Fresh Feed	Recycle	Furnace Charge	Furnace Effluent	Demethaniser			Ethylene Tower		Deethaniser		Depropaniser	
					Feed	Overhead	Bottoms	Overhead	Bottoms	Overhead	Bottoms	Overhead*	Bottoms
H_2	.....	.....	.....	229.0	229.0	229.0	.....	.....	.....	.....	.....	.....	.....
CH_4	.....	.....	.....	406.0	406.0	404.0	2.0	2.0	.....	.....	.....	.....	.....
C_2H_4	.....	3.0	3.0	354.0	354.0	15.0	339.0	336.0	3.0	3.0	.....	.....	.....
C_2H_6	16.0	74.0	90.0	87.0	87.0	1.0	86.0	10.0	76.0	74.0	2.0	2.0	.....
C_3H_6	.....	11.6	11.6	97.8	97.8	.....	97.8	.....	97.8	2.0	95.8	95.8	.....
C_3H_8	544.0	129.0	673.0	134.8	134.8	.....	134.8	.....	134.8	.....	134.8	131.0	3.8
C_4H_8, C_4H_6	.....	1.0	1.0	12.7	12.7	.....	12.7	.....	12.7	.....	12.7	1.0	11.7
C_5+	.....	.....	.....	23.1	5.0	.....	5.0	.....	5.0	.....	5.0	.....	5.0
TOTAL	560.0	218.6	778.6	1344.4	1326.3	649.0	677.3	348.0	329.3	79.0	250.3	229.8	20.5

* To C_3 Separation Facilities.

TABLE 2

Material Balance for Ethylene-Propylene—Plant Based on n-Butane (Plant B)

Basis: 75 Mm Pounds Per Year Ethylene, 8000 Hours Per Year, 90 Percent nC_4H_{10} Conversion

Flows in pound moles per hour

COMPONENT	Fresh Feed	Recycle	Furnace Charge	Furnace Effluent	Demethaniser			Ethylene Tower		Deethaniser		Depropaniser	
					Feed	Overhead	Bottoms	Overhead	Bottoms	Overhead	Bottoms	Overhead	Bottoms
H_2	.....	.....	.....	134.0	134.0	134.0	.....	.....	.....	.....	.....	.....	.....
CH_4	.....	.....	.....	437.1	437.1	435.1	2.0	2.0	.....	.....	.....	.....	.....
C_2H_4	.....	.....	.....	354.0	354.0	15.0	339.0	336.0	3.0	3.0	.....	.....	.....
C_2H_6	.....	.....	.....	64.0	64.0	1.0	63.0	10.0	53.0	51.0	2.0	2.0	.....
C_3H_6	.....	3.0	3.0	136.2	136.2	.....	136.2	.....	136.2	2.0	134.2	131.2	3.0
C_4H_8, C_4H_6	.....	20.8	20.8	21.8	21.8	.....	21.8	.....	21.8	.....	21.8	1.0	20.8
C_4H_{10}	492.3	54.7	547.0	54.7	54.7	.....	54.7	.....	54.7	.....	54.7	.....	54.7
C_5+	1.7	2.0	3.7	48.3	11.0	.....	11.0	.....	11.0	.....	11.0	.....	11.0
TOTAL	494.0	80.5	574.5	1250.1	1212.8	585.1	627.7	348.0	279.7	56.0	223.7	134.2	89.5

To store fertilizer, Brea is building . . .

WAREHOUSES–FOOTBALL–FIELD STYLE

Four warehouses were completed recently to furnish storage for 20 million pounds of prilled ammonium nitrate fertilizer produced by Brea Chemicals, Inc., subsidiary of Union Oil Company of California. Each warehouse is 320 feet long by 80 feet wide.

McDonald Bros., construction company for the warehouses, moved about 150,000 tons of hard forming sandstone deposits.

It was required that the warehouses be located well below the crests of the surrounding hills.

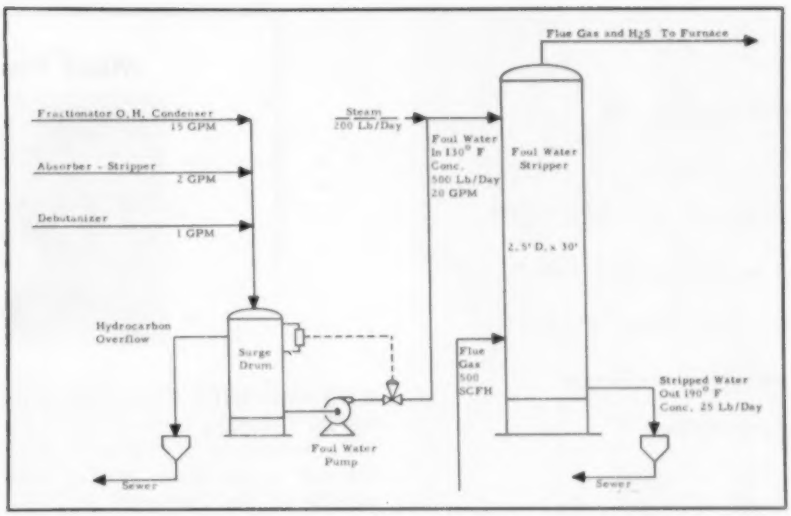

FIGURE 1—Flow diagram shows simple equipment required.

How to Eliminate H_2S Odors

In cat cracker operating area, waste flue gases are used to strip H_2S from foul water before it reaches the sewer.

Richard C. Shea and Jack Hackathorn,
Cities Service Oil Company,
Bartlesville, Oklahoma

NO REFINER needs to be sold on the desirability of eliminating the source of such an obnoxious and toxic gas as H_2S from an operating unit area. Engineers at the Cities Service Oil Company, Ponca City, Okla., refinery, working on this problem, have hit upon an inexpensive and satisfactory solution.

By making use of the heat and stripping qualities of a source of waste flue gas, the quantity of hydrogen sulfide has been reduced by approximately 85 percent and the odor has been eliminated.

Source of Hydrogen Sulfide—The operating unit concerned is a catalytic cracking unit. The overhead vapors from this unit contain considerable quantities of steam, ammonia and hydrogen sulfide. When the steam condenses in the overhead condensers of the fractionating tower, part of the ammonia and hydrogen sulfide is absorbed by the steam condensate producing a solution of ammonium sulfide. Similarly, ammonium sulfide solutions are produced by the absorber-stripper and debutanizer towers.

These condensates in the past were drawn off to the sewer. The high concentration of hydrogen sulfide plus the reduction in pressure caused the release of rather large quantities of the gas to the atmosphere. This resulted in severe air pollution near the unit area and corrosion of ferrous materials in the immediate vicinity. Table 1 shows the average water withdrawal rate and concentration of hydrogen sulfide in each of the streams mentioned.

TABLE 1

Stream Source	Water Flow Rate—gpm	Conc. H_2S ppm	Lbs. H_2S per Day
Fractionator O.H.	15	900	160
Debutanizer	1	11,000	130
Absorber—Stripper	2	9,000	220

Process and Flow—From experimental work in the laboratory and field, it was found that the hydrogen sulfide could be removed by heating and stripping it with the flue gas available at the unit site and would give the desired results with a minimum investment and operating cost.

This operation required that the water be heated to a temperature of 190 to 195 F. and then contacted with the flue gas. Because the flue gas itself is available at a temperature of about 1000 F., it is used to supply part of the heat required. In this case it supplies approximately half of the necessary heat.

Figure 1 is a schematic flow diagram of the system used at the Cities Service Refinery. The contaminated water streams are collected in a surge drum from the unit towers. No pumps are required to collect these streams as the tower pressures provide sufficient head for their movement.

The surge drum was installed as a safety measure to trap and prevent any hydrocarbons being carried into the stripper. This was necessary because the flue gas and hydrogen sulfide leaving the stripper is injected into a furnace for combustion of the hydrogen sulfide, and the inclusion of any large amount of a hydrocarbon could cause operating difficulties on that furnace.

A level is maintained in the surge drum with an interface level control and any hydrocarbons, which may collect in the drum, flow to the oil sewer through an overflow line which is located directly above the water level in the drum.

The stripper charge pump takes suction from the surge drum and pumps the water into the top of the stripper. The stream is partially heated just before entering the tower by steam which is injected directly into the line.

The outlet water from this tower having been stripped of about 85 percent of the hydrogen sulfide flows directly into the sewer.

The flue gas flows into the bottom of the tower through a distribution spider. Because of the small quantity of catalyst contained in the flue gas, the spider directs the gas downward to minimize the possibility of plugging the spider. The flue gas plus the hydrogen sulfide removed from the water pass out the top of the tower. This gas is then injected into a gas fired process furnace immediately below the burners where the hydrogen sulfide is burned.

Tower Description—The stripper is a 2.5-foot (diameter) by 30-foot carbon steel tower. It has no trays but does have a seven foot section of

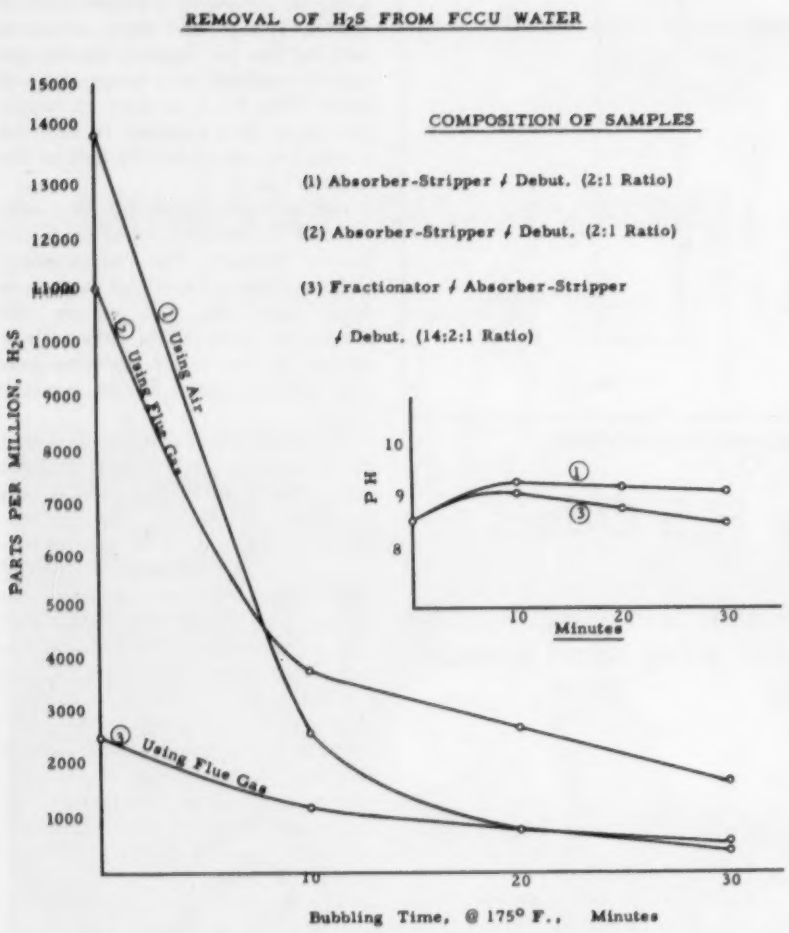

FIGURE 2—These lab tests were made to find a satisfactory removal process.

Raschig ring packing located immediately above the flue gas inlet to distribute the flue gas evenly. A 27-foot level of water is maintained in the tower during its operation which protects it from hydrogen sulfide corrosion and provides the necessary contact time between water and flue gas. Since the corrosion attack by hydrogen sulfide is most severe in the vapor phase, only the top section of the tower requires corrosion protection.

Basic Reactions—Ammonia and hydrogen sulfide combine to form ammonium sulfide and ammonium hydrosulfide. The reactions are reversible and decomposition of these compounds in a water solution readily occurs with the addition of heat to produce the original reactants.

$$NH_3 + H_2S \underset{\Delta}{\overset{H_2O}{\rightleftharpoons}} NH_4HS$$

$$2NH_3 + H_2S \underset{\Delta}{\overset{H_2O}{\rightleftharpoons}} (NH_4)_2S$$

As hydrogen sulfide oxidizes to free sulfur, the free sulfur dissolves in the ammonium sulfide solution to form ammonium polysulfide.

$$(NH_4)_2S + S_x \overset{H_2O}{\rightarrow} (NH_4)_2S_x$$

Removal of Hydrogen Sulfide—The reactions shown above were the basis of laboratory work undertaken to find a satisfactory process for the removal of the hydrogen sulfide from the contaminated water streams.

The ammonium sulfide solutions produced by the catalytic cracker fractionator columns were subjected to several types of laboratory tests. Typical results are shown in Figure 2.

Curve 1, Figure 2, was obtained in the laboratory by blowing a solution containing 14,000 ppm as hydrogen sulfide with air at 175 F. for 30 minutes. At the end of this time the solution contained 440 ppm as hydrogen sulfide. Curve 2 was obtained by blowing a similar sample with flue gas. This test was conducted at the unit site where flue gas was injected into the sample by means of a copper line connected to the stack. The temperature was maintained by keeping the sample in a water bath which was heated with a steam coil. The hydrogen sulfide content was lowered from 11,000 to 1760 ppm.

The lower final results shown on Curve 1 were probably due to additional oxidation of hydrogen sulfiide to free sulfur by the oxygen in the air and to the difficulty in maintaining the elevated temperature required when running the test for Curve 2.

A sample approximately the anticipated composition of the proposed stripper feed gave the results shown by Curve 3. Hydrogen sulfide re-

Meet the

RICHARD SHEA joined Cities Service Oil Company at the Ponca City, Okla., refinery in 1950, after receiving his B.S. in petroleum refining engineering at the University of Tulsa. Now a process engineer in the home office at Bartlesville, Shea received assignments at the Ponca City refinery which included a year in the Engineering-Maintenance department, a year as an operating-shift foreman and two years in the Process Engineering department.

JACK HACKATHORN is a chemist at the Ponca City refinery. He was

Authors

with Phillips Petroleum Company at its butadiene plant in Borger, Texas, when he entered the Army in 1944. He served as an Armed Forces Institute instructor in the Philippines and was discharged in 1946. After leaving the service, he returned to the University of Tulsa, where he had received his bachelor's degree in 1943, and started work on his master's which he completed in petroleum sciences. He worked at the Stanolind Oil & Gas Company's synthol project at Garden City, Kansas until its cancellation in 1949, when he joined the Cities Service organization.

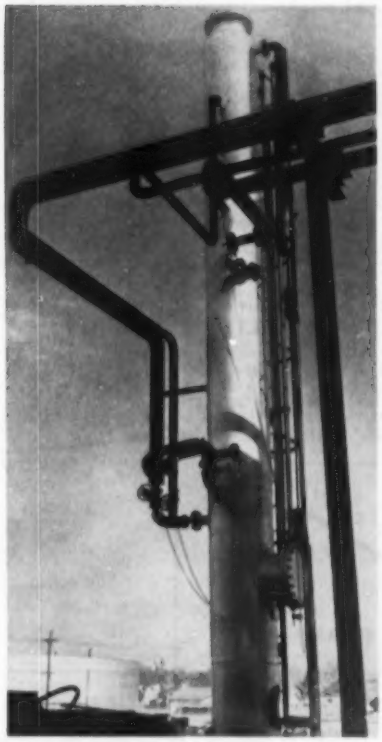

FIGURE 3—Stripper tower has no trays but does have a seven-foot section of Raschig rings.

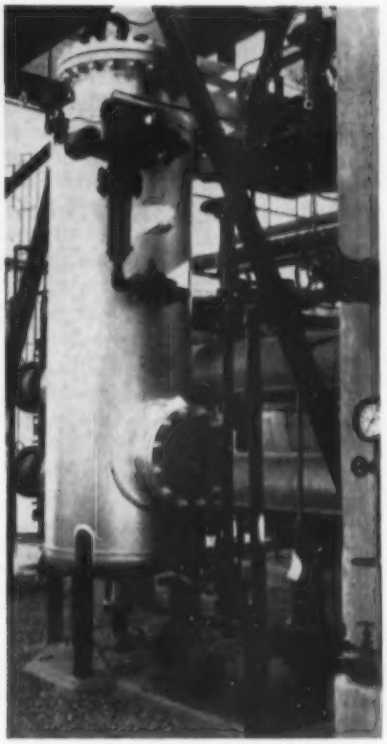

FIGURE 4—Surge drum prevents hydrocarbon slugging into furnace gas system.

moval was about 80 percent at 175 F. Tests at 190 F. indicated that 85 to 90 percent removal of hydrogen sulfide could be expected at the higher temperature.

Test Method[1]—Hydrogen sulfide was determined by the standard iodimetric procedure in which an excess of iodine solution is added to a sample and the unreacted iodine titrated with sodium thiosulfate. This test is used as a rapid control method and is only approximate since other substances interfere with the test to some extent. This is the reason for listing the concentration of hydrogen sulfide as so many "ppm *as* hydrogen sulfide."

Effect of Adding Acid—The addition of hydrochloric acid to solutions containing 600 to 700 ppm as hydrogen sulfide reduced the concentration to around 13 ppm when the solutions were agitated with either air or flue gas. Acid was added until the methyl orange end point was reached.

If a supply of spent acid is available in the plant this gives a good method of effecting practically 100 percent removal of hydrogen sulfide. The use of fresh acid, however, would be too expensive.

pH Change During Tests—It is interesting to note (see Figure 2) that the pH of the solution rose sharply during the first ten minutes of the test when the hydrogen sulfide was evolving most rapidly. During the remainder of the test, the pH declined slowly. This indicates that most of the hydrogen sulfide is rather loosely held in solution and its removal allows a rise in the pH of the solution. The balance of the hydrogen sulfide is presumably combined with ammonia as ammonium sulfide or ammonium hydrosulfide which decomposes at a much slower rate, and with a corresponding increase in pH.

Laboratory Results Vs. Stripper Operation—The solubility of hydrogen sulfide in water[2] is 765 ppm at 175 F. and 410 ppm at 195 F. and results of this magnitude were obtained in the laboratory when using flue gas as the stripping agent. Lower results were obtained when using air due to oxidation of the sulfur compounds as previously mentioned.

The operation of the stripper produced effluents ranging in hydrogen sulfide content from 490 to 780 ppm depending upon the operating conditions. Table 2 summarizes the operations of the stripper.

TABLE 2

Run No.	Ppm In	Ppm Out	Temp. Out
1	2,600	780	155° F.
2	2,100	760	166
3	2,100	500	175
4	2,600	600	190
5	1,600	490	190
6	2,600	500	195

From these results it can be seen that this particular operation actually involves the destruction or breakdown of poly sulfides into hydrogen sulfide by the addition of heat. By stripping the hyrogen sulfide from the solution as it is formed, the concentration is reduced to a point where it is no longer a nuisance.

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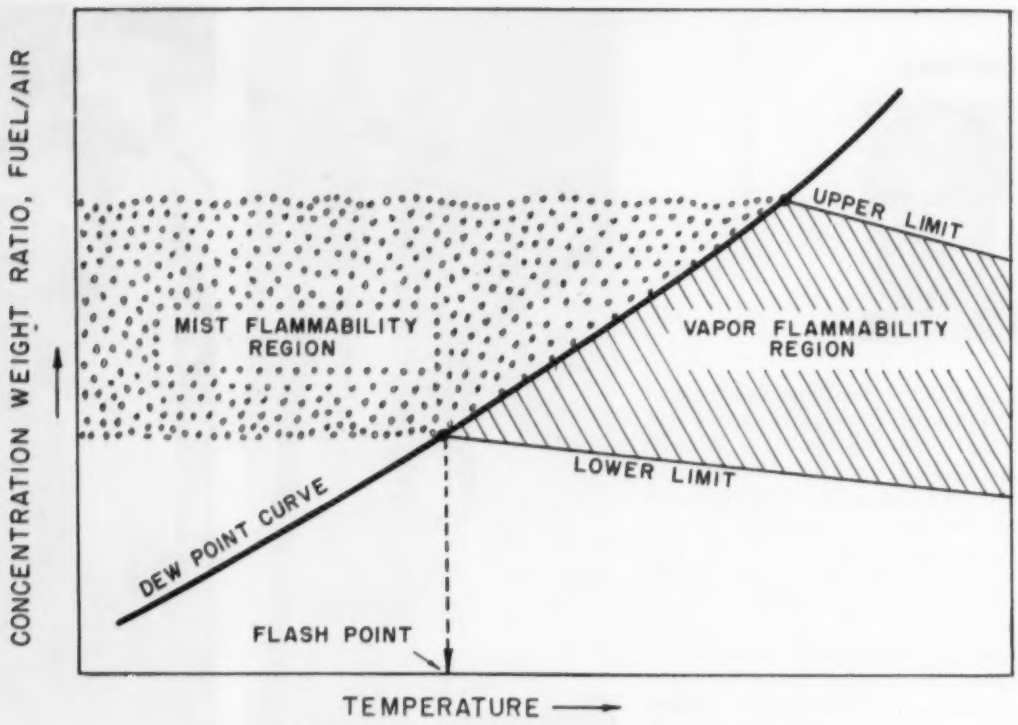

FIGURE 1—Schematic flammability diagram at constant pressure.

Careful! Mists Can Explode

Contrary to popular opinion:

- **Mists can propagate flames.**
- **Vapor pressure is a poor index for judging mist flammability.**

J. Eichhorn,
The Dow Chemical Company,
Midland, Michigan

REFINERY AND chemical plant personnel are as a rule aware of the hazards of gas explosions. The handling of flammable liquids in open systems is considered safe at temperatures below the flash point. It is not commonly realized, however, that mists of combustible liquids at temperatures well below their flash points can be fully as explosive as vapor-air mixtures. The recent report of a mist explosion in the chemical industry prompted an experimental and literature study of mist combustion.

Sufficient experimental combustion work was done to demonstrate that mists of flammable liquids at temperatures well below their flash points would propagate flames. The test liquids (at room temperature) were atomized into an open 11″ x 30″ glass pipe with a two-phase nozzle. An explosive mist concentration was obtained by appropriate adjustment of the fuel/air ratio and then ignited by a high voltage discharge. Eight liquids (Table 1) ranging in flash point from 110 to 615 F. were ignited in the apparatus. Mist of the 615 F. flash peanut oil propagated flames as readily as the 110 F. Stoddard. Only the o-dichlorobenzene propagated flames with difficulty. This experimental work quickly showed that (1) mists of flammable liquids can propagate flames, (2) vapor pressure is a poor index for

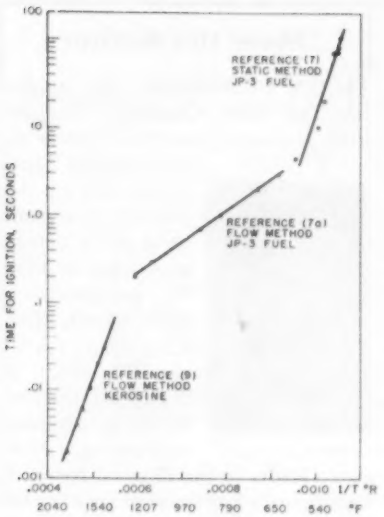

FIGURE 2—Ignition delay as a function of temperature.

judging mist flammability, and (3) mists of chlorinated compounds are partially self-quenching.

Before proceeding with a discussion of the factors involved in mist combustion, a few general remarks on combustion might be of value. In this discussion, the term "combustion wave" is to be thought of as a burning zone propagated through a flammable medium by heat and mass transfer processes at a velocity less than that of sound. The wave is sustained by a continuous transfer of heat from the reaction zone to the preheat zone where the unburned fuel is brought to ignition temperature.

Mist Formation—Dispersions of liquid droplets in air can be obtained by atomizing the fluid or by flashing the hot liquid and subsequently quenching the vapor with a cold gas. In refinery operation, a break in a hot oil line could result in considerable mist formation by such a flash-quench operation. Droplet diameters in mists formed by this technique range in size from about 0.5 to 10 microns—with the major portion in the 10 micron range.[5, 7] Although particle size is expected to be a factor in mist explosions, no quantitative data are available. Hartmann[6] reports that for dust explosions a decrease in particle size is accompanied by a decrease in the minimum energy required for ignition. This could well be true for mist particles. For the smaller drop, less heat is required to bring the liquid to the ignition temperature. Thus one might expect a decrease in minimum ignition energy with decreased particle size. It is also known that very fine particles exert a greater vapor pressure than that observed over extended surfaces. Calculations indicate, however, that this is a factor only for mist particles below .01 microns.

TABLE 1

Properties of Experimentally Ignited Mists

LIQUID	Flash (°F.)	Density (60 F.) g/cm³	Viscosity (100 F.) Centistokes
Stoddard	110 Closed	.77	.98
Dispersol	160 Open	.79	1.75
Dowtherm E[1]	155 Open	1.31	0.76
Dowtherm A[2]	255 Open	1.07	2.8
Mineral Seal	270 Open	.84	4.9
150 N HVI	395 Open	.87	33
300 N HVI	445 Open	.88	67
Peanut Oil	615 Open	.92	42

Note: Heats of vaporization at the boiling point for these compounds range from about 120-160 B.t.u. per pound.
[1] O-dichlorotenzene.
[2] 76.5 percent Diphenyloxide, 23.5 percent Diphenyl.

Ignition—Mist ignition can be initiated by what are termed massless sources (sparks, open flames) or heated bodies (hot wires, projectiles). In the Lewis and von Elbe concept of combustion[8] the heat transferred from the reaction zone to the pre-heat zone is thought of as an enthalpy excess. The heat has to be furnished either by the ignition source or by the burning operation. For a spherical combustion wave it can be shown that below a certain critical wave diameter the combustion process is not self-sustaining and the energy for wave propagation must be added by an ignition source. For ignition by minimum energy it is necessary that the energy be transferred in a volume small in relation to the volume at critical diameter and in a time interval short compared to that required for growth to the critical diameter.

In this period of wave growth the energy from the ignition source per unit area of wave front continuously decreases while the energy from chemical reaction continuously increases. As a result the system passes through a minimum energy condition. If this minimum energy is greater than that required to sustain the reaction, the flame propagates. The wave front attains this energy condition in about 200 microseconds.[1] A self-propagating flame attains a steady temperature and flame velocity after about 1000 microseconds.[11] Minimum energies required to ignite vapor-air mixtures under specified conditions have been reported by Lewis and von Elbe.[8] No such data are available for mist explosions, but it is recognized that more energy is required, probably because of the vaporization step.

Ignition can take place with sources below the flame temperature, but the minimum energy requirements are higher at lower temperatures because the rate of chemical reaction drops off rapidly. To promote combustion at these conditions a larger mass of the flammable medium must be heated, deeper heat penetration is required, and a correspondingly larger expenditure of energy is needed. The minimum time required for ignition under these conditions increases sharply as the source temperature decreases. Literature ignition delay data for both static and flow conditions are plotted in Figure 1. The data all follow the $\log \Theta = \frac{A}{T} + B$ relationship first reported by Lloyd.[9] Lloyd's work is of special interest since it was done by spraying fuels (kerosine, etc.) into a hot flowing air stream. The data show the rapid increase in ignition temperatures required at the low delay times. Under outdoor conditions with normal air movement ignition of flammable mists by heated bodies would probably take place only if very short delay times were required. This would require a very hot source.

Numerous additional ignition techniques have been reported. Of special interest are a series of studies undertaken to simulate ignition by welding sparks, etc.[8] The data show a marked increase in ignition temperature with a decrease in particle size. Temperatures in the order of 1800 F. were required for 0.5 mm diameter particles. The possibility of igniting mist systems by sparks from grinding or welding operations would seem to be rather remote.

Combustion—Recent work by Godsave[4] on the burning of single fuel drops is of considerable interest in the field of mist explosions. Godsave found that the burning rate of the particles was not dependent on vapor

TABLE 2

Additives to Form a Non-flammable Spray* Oil—1430 F. Minimum Ignition Temperature

GASEOUS ADDITIVES

Type	Percent of Vapor	
N_2	30	
CO_2	22	Remainder Air
CH_3Br**	5.2	

LIQUID ADDITIVES

Type	Parts/Part of Oil (Wt.)
Carbontetrachloride	3.9
Chloroform	5.0
Dichloroethylene	11.0
Trichloroethylene	6.0
Tetrachloroethylene	4.1
Methyl Bromide	>5.0
Bromoform	1.75
Methyl Iodide	5.1
Methylene Iodide	1.6
Water†	0.5††

* Ref. Burgoyne, J. H. and Richardson, J. F., Fuel 28, p. 2 (1949).
** Chemical quenching type additive.
† Chemical quenching effectiveness about that of CH_3Br.
†† Plus 2-3 percent triethanolamine to emulsify water and oil.

pressure, but rather depended almost entirely on the heat necessary to bring the droplet to its boiling point and evaporate the liquid. Thus the heat of vaporization at the boiling point rather than the vapor pressure of the fluid is of fundamental significance in mist explosions. Recent work by Simpson[12] on the burning of individual particles likewise indicated that significant vaporization preceded ignition of the vapors. Burning took place when the drop surface was close to the boiling point. Godsave also showed experimentally that the mass rate of change of a burning particle was proportional to the particle diameter. The larger particles in a mist burn at a greater rate than the smaller ones. The life of a burning particle, however, can be shown to be proportional to its original diameter squared. Thus the small particles actually disappear before the large ones.

The analysis of a complete spray has been reported by Wolfhard and Parker.[13] In this work a kerosine spray was fed continuously to a burner. The flame consisted of two regions: (1) a pre-heat zone, and (2) a luminous zone where the reaction took place. In such an operation most of the heat (95 percent) for fuel evaporation is transferred to the particle by convective mechanism rather than by radiation. The time to evaporate a 10-micron kerosine droplet in the pre-flame zone is about 25 milliseconds. Additional data which substantiate the vaporization-ignition mechanism are reported by Haber[5] and Jones.[7] They found that the lower limit of flammability (expressed as pounds fuel/pound air) for fine droplets is essentially identical to that for the vapor-air mixture. This is shown in the schematic flammability diagram of Figure 1. The familiar vapor flammability region is of importance only at temperatures above the flash point. The mist flammability region, however, extends below this temperature. Thus mists of flammable liquids can be a hazard even at temperatures well below the flash point. Present data indicate that the concentration limits of flammability for mists and vapor-air mixtures are approximately identical at the same pressure.[7]

Although the proper fuel/air ratio is essential for combustion, the homogeneity of the mist is an all-important factor in the propagation of the flame. Experimentally Haber[5] found that the explosion velocities were slightly lower in mists than in vapor-air mixtures but increased some with increasing droplet concentration. Large mist particles gave uneven burning rates.

Quenching—Mists can be made non-flammable by additives which inhibit flame propagation. As mentioned previously, heat has to be transferred to the mist for vaporization and ignition. The flame is effectively quenched if sufficient heat is removed rapidly enough from the burning zone to prevent flame propagation. Non-flammable gaseous additives such as N_2 and CO_2 (see Table 2) can sufficiently dilute the mist to such a point that insufficient heat is available for flame propagation. The relative effectiveness of the various gases depends in part on their density, specific heat and thermal conductivity. Heat quenching by evaporation of non-flammable additives is also highly effective. Burgoyne and Richardson[2] report that oil mists can be made non-flammable by the addition of water to the spray mixture. The rapid removal of heat by the evaporation of the water quenches the flame. Flames can also be very effectively quenched by the addition of materials which chemically inhibit the burning process. Numerous mechanisms of burning have been postulated.[8] In these the OH radical plays an important part. By reacting the OH radical with either HBr, HI, or HCl[10] the burning process can be effectively stopped. Additives of this type were tried by Burgoyne and Richardson[2] and are listed in Table 2. Halogen effectiveness for flame quenching follows the pattern I>Br>Cl.

Conclusions—Mists of flammable liquids can be fully as dangerous as vapor-air mixtures. Fuel factors such as heat of vaporization and chemical composition are much more significant than flash point for evaluating the hazardous nature of mists. Concentration limits of flammability for mists and vapor-air mixtures are approximately identical.

Meet the Author

JACOB EICHHORN had worked for The Dow Chemical Company three summers as a student from the University of Michigan when he joined the company on a permanent basis in 1950. His assignment to the Midland, Mich. division came shortly after he completed his doctorate in chemical engineering. Now group leader in the Physical Research Laboratory's Engineering division, Dr. Eichhorn has served the university as a lecturer in its graduate chemical engineering program at Midland. Active in the AIChE section there, he has held posts as program chairman, head of the education committee, member of the executive committee, and recently was elected secretary. He is co-author of three technical articles and has made application for a number of patents.

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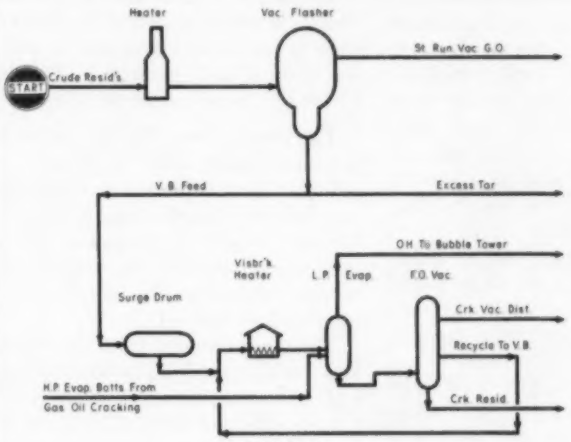


FIGURE 1

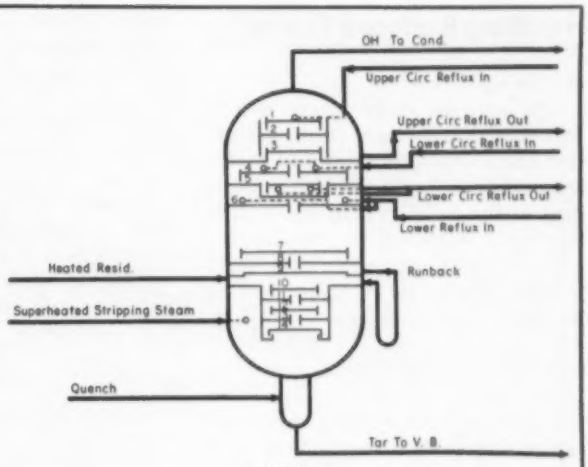


FIGURE 2

Handling Reduced Crudes

Substantial gains are made in gasoline, LPG, and solvent yields by vacuum flashing and visbreaking.

Forrest S. Allinder
Union Oil Company of California
Wilmington, California

VACUUM flashing of the 10° API residuum from crude fractionation, followed by visbreaking of the flasher tar bottoms, increases the recovery of feed stocks for the catalytic cracking units and reduces the production of residual fuel oil at the Los Angeles refinery of Union Oil Company of California. The gas oil recovered at the vacuum flasher is subsequently cracked in the Fluid catalytic cracking unit to produce high octane gasoline. Visbreaking of the flasher tar produces additional gasoline and gas oil stocks, reducing the quantity of cutter stock required for fuel oil blending.

Flashing the reduced crude oil at 775 F. and 75 mm. Hg. absolute yields about 45 percent of 17° API gas oil, and 55 percent of 5° API tar. Visbreaking of the tar yields about 9 percent of 400 F. endpoint gasoline, 16 percent of 400 — 725 F. endpoint gas oil and 75 percent of 1.4° API cracked residuum.

A simplified flow diagram of the residuum processing systems is shown in Figure 1. The combined residua from crude distillation units flow to the vacuum flashing unit, are heated to 775 F. and are passed to the vacuum flashing column. Heavy vacuum gas oil is flashed off and the tar bottoms are pumped without intermediate cooling to the visbreakers. Excess tar (above visbreaker charge capacity) is produced directly to straight run fuel oil storage. The visbreaker reaction products flow to the low pressure evaporators where the lighter oils are flashed. The heavy bottoms from the low pressure evaporators flow to the fuel oil vacuum tower where heavy oils, suitable for cutter stock or visbreaker cycle stock, are flashed and removed. The bottoms product from this final tower is blended with cutter stocks to produce bunker fuel oil.

Meet the Author

FORREST S. ALLINDER is a process engineer with Union Oil Company of California at its refinery in Los Angeles. A chemical engineering graduate from California Institute of Technology, where he also received a master's degree, Allinder joined Union Oil in 1950. His duties with the company have included both process design and plant operation. A registered engineer in California, he is a member of CNCA and AIChE.

The visbreaker system is actually part of a combination thermal cracking unit. The unit consists of two identical cracking sections, operating in parallel, with the light products going to a common stabilizer and the heavy products going to a common fuel oil vacuum tower. Light and heavy catalytic gas oils are cracked in separate heaters and flow to the high-pressure evaporators. Here the light oils are flashed overhead and the residua flow to the low-pressure evaporators.

Vacuum Flashing Unit Operation

The many unique features of the vacuum flashing unit are best presented by a description of the tower

and its operation.

The vacuum flasher receives 10° API residua from three crude distillation units without intermediate cooling or storage and at sufficient pressure so that no feed pump is required. The flows of two of the streams are level controlled, while the third (which amounts to about one-half of the total charge) is flow controlled. The feed, at about 675 F., is split into four parallel streams and flows to the heater. These streams are measured and controlled by flow controllers, which in turn are reset by a pressure controller whose sensing element is located in the common header just upstream of the flow controller motor valves. This system of heater charge control adjusts for fluctuations in the feed rate to the unit as the flows from the three crude units vary.

The four residuum streams are heated to 775 F. Steam, at a pressure of 30 psig, flows through separate tubes in the same heater and is superheated to about 750 F. The heated residuum and superheated steam are transferred to the vacuum flashing column through separate lines.

The vacuum flasher tower contains 14 bubble cap trays. It is lined with type 316 stainless steel from Tray 5 to the bottom. All bubble caps and trays except Tray 1 are made of type 316 stainless steel. Tray 1 is made of carbon steel. A diagram of the tower is shown in Figure 2. The tower has three sections: The upper section serves as a heat exchanger for cooling and condensing the vacuum gas oil, the middle section serves as a fractionator, and the bottom section serves as a stripper. The flasher operates with a pressure of about 75 mm. Hg. absolute at the flash zone. The circulating reflux streams which condense and cool the vacuum gas oil are adjusted to maintain heat balance in the tower.

The heated residuum feed enters above Tray 10 through a tangential inlet. The liquid from the feed, plus the runback liquid, flows down through five stripping trays (10-14) countercurrently to the superheated stripping steam. The tar at about 670 F. accumulates in the "boot" and is pumped to the tar surge drum or to fuel oil storage.

The four trays (6-9) just above the feed inlet make up the fractionating section. This section is provided to reduce entrainment and to fractionate out heavy metal contaminants from the vacuum gas oil. Liquid runback from the fractionating section flows through an external line from Tray 9 to Tray 10. The amount of runback is controlled by the rate of hot lower reflux to the top of the fractionating section (Tray 6).

Two trays (4-5) above the fractionating section cool the rising vapor and condense approximately 90 percent of the tower overhead stream. All liquid runback is drawn off on Tray 5 to the circulating reflux surge drum. A small part of this hot stream is returned directly to Tray 6 as hot lower reflux. Cooled lower circulating reflux at 400 F. is returned to the top of the main condensing section (Tray 4). The excess gas oil from the circulating reflux drum joins the upper circulating reflux stream from Tray 3 and is further cooled to 200 F. A portion is further cooled to about 165 F. to provide top reflux. The remainder is pumped to storage.

Final oil condensing and vapor cooling is done in the top three trays. Most of the overhead vapor is steam. All liquid runback is drawn off on Tray 3 and flows to the heat exchange system. Cooled upper circulating reflux is returned to Tray 1 to control the tower top temperature.

The vapor leaving the top of the vacuum tower is mainly steam plus some oil vapor, air and light hydrocarbons. Most of the stream is condensed in the overhead condensers and flows by gravity to the overhead separator. Non-condensible vapors are disengaged in the overhead condensers and flow to the two-stage vacuum ejector system. Condensate from the ejector system flows by gravity to the overhead accumulator through suitable seals. Non-condensible vapor from the final ejector stage normally is discharged directly to a steam atomized low pressure waste gas burner in the vacuum heater to eliminate emission of hydrocarbon to the atmosphere.

Some cracking of the tar bottoms may occur in the tower if the residence time is excessive. The small diameter "boot" is provided to minimize the residence time yet maintain a high bottom temperature. Since the tar bottoms pass directly to visbreaker heaters without intermediate cooling, a considerable fuel saving is realized.

To further reduce cracking in the "boot," a small portion of the tar bottoms is cooled and returned on manual control as "quench." The tar leaves the "boot" at about 695 F.

Tar Production—The tar from the vacuum flasher may be produced either to the visbreakers or to straight run fuel oil. Charge rate to the visbreakers is held at maximum, but tar production normally exceeds the visbreaker capacity. The excess tar is produced to fuel oil.

The tar is pumped from the "boot" and flows to production on level control. The production stream splits into 2 parts. The first flows directly to the visbreaker charge drum without further cooling. The second flows through the 170 psig tar steam generator where it is cooled to about 450 F. The tar stream leaving the 170 psig steam generator splits into two parts. The first returns to the flasher "boot" as quench. The second is passed through the 30 psig steam generator on flow control where it is cooled to about 340 F. Cutter stock is added to the tar leaving the 30 psig steam generator and the cutback tar flows through a final water cooler. The cutback tar flows to fuel oil storage at about 140 F.

Heavy Metals in Vacuum Gas Oil—The gas oil from the vacuum flasher is blended with other straight run distillates for feed to the FCC unit. To avoid excessive hydrogen make at the catalytic cracker, the heavy metals content (the sum of Cu, V and Ni) must be minimized. (Careful control of the runback is necessary to control metals.) The heavy metals content of the vacuum gas oil is consistently less than 0.1 ppm.

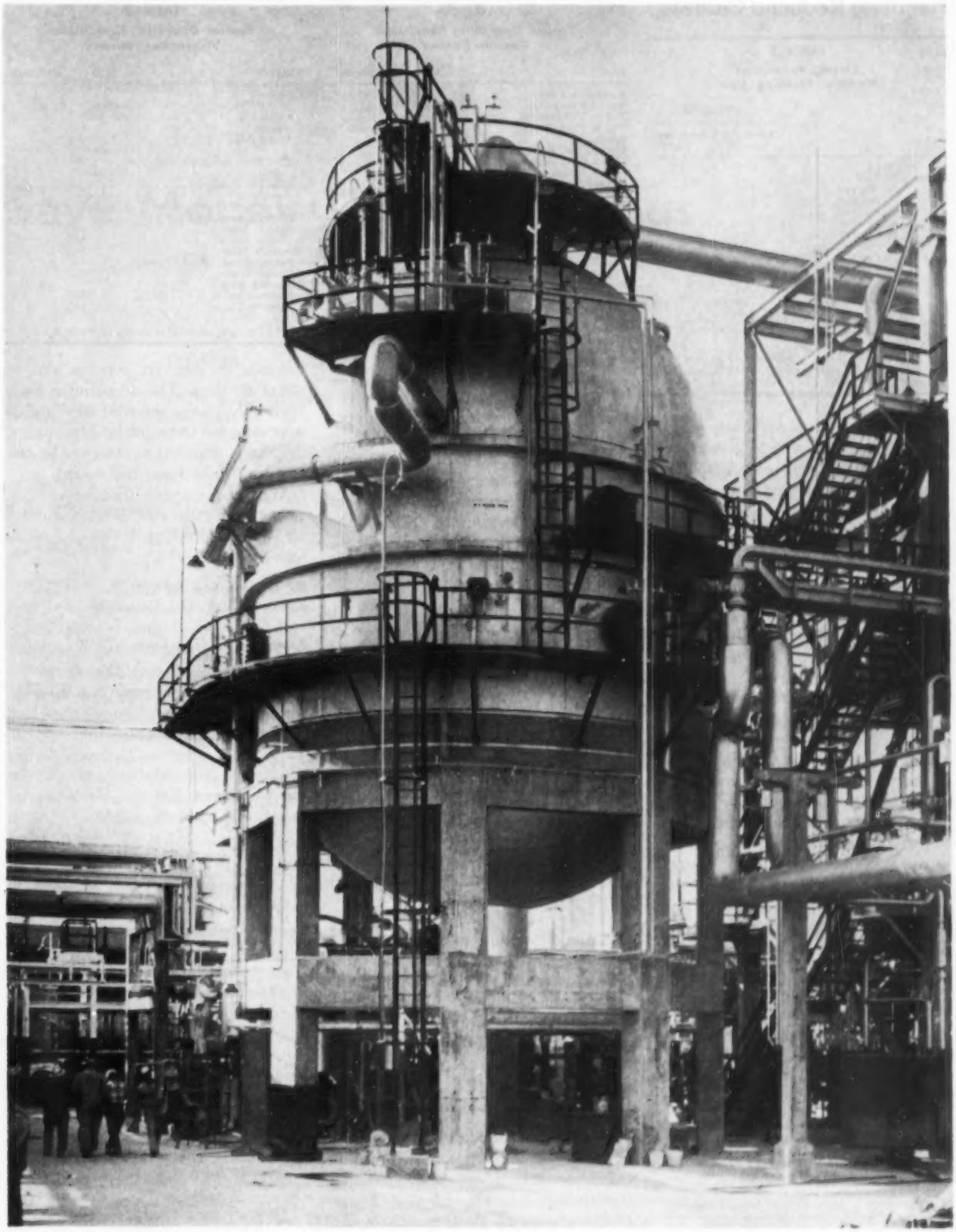
Stream Properties and Yields—The properties of the feed and product streams from the vacuum flasher are presented in Table 1. Vacuum gas oil yield varies with feed composition but normally is about 40 to 45 percent.

Typical operating conditions for the tower are presented in Table 2.

Visbreaking Vacuum Flasher Tar

By visbreaking the tar from the vacuum flasher, the quantity of cutter stock required for fuel oil blending is reduced and additional gasoline and gas oil cracking stocks are recovered.

The vacuum flasher tar is pumped without cooling to a surge vessel at a Combination Thermal Cracking Unit. The tar stream from the surge drum



The vacuum flashing tower, one of the largest of its kind in the world, has a capacity of approximately 40,000 b/d. Straight run residuum is distilled at 775 degrees F. to flash off about 40 percent of heavy gas oil suitable for catalytic cracking. Flasher bottoms are sent to visbreakers.

TABLE 1
Stream Properties
Vacuum Flashing Unit

TEST	STREAM	
	Vacuum Gasoil	Vacuum Tar
Gravity, °API	17.2	4.9
Engler[1], °F IBP	380	
10 Percent	715	
20 Percent	775	
30 Percent	810	
40 Percent	830	
50 Percent	840	
60 Percent	870	
70 Percent	890	
80 Percent	910	
90 Percent	925	
Max.	940	
Percent Rec.	95	
Color	6	
Viscosity SSU @ 100	580	
Pour Point °F	90	
Penetration @ 77 F.	---	9

[1] Vacuum Engler, converted to atmospheric pressure.

TABLE 2
Typical Operating Conditions
Vacuum Flasher

Flow	B/D	Percent
Residuum Feed	40,800	100
Vacuum Gas Oil	17,000	41.5
Tar to Visbreakers	19,500	47.5
Tar to Fuel Oil	4,200	10.5
Runback	2,300	
Upper Circ. Reflux	7,700	
Lower Circ. Reflux	50,000	
Lower Reflux	1,650	
30 psig Steam	(15,000 lb/Hr.)	
Temperatures, °F.		
Heater Inlet	665	
Heater Outlet	775	
Flash Zone	725	
Top	207	
Tray 3	402	
Tray 5	510	
Boot	696	
Tar to Visbreakers	674	
Tar from E-2	486	
30 psig Steam (Stripping)	764	
Pressure		
Flash Zone, MM. Hg. Absolute	75	
Heater Pressure Drop, psi	63	

TABLE 3
Typical Operating Conditions
Visbreaker Heaters

FLOW	B/D	Percent
Charge		
5° API Tar	10,020	95.8
Cycle Oil	430	4.2
Products		
Fixed Gas[1]	(1,100 mcfd)	
C_4-425 F. endpoint gasoline	1,040	10.0
425–725 F. gas oil	1,620	13.9
Residuum	7,810	71.9
Temperatures, °F.		
Heater Inlet	660	
Heater Outlet	815	
Soaker Inlet	815	
Soaker Lower Roof Outlet	855	
Soaker Outlet	865	
Pressure, psig		
Furnace Inlet	555	
Furnace Outlet	350	

[1] Fixed gas analysis is shown in Table 4.

is split into two parts. Each part is joined by a small recycle stream from the fuel oil vacuum tower and flows to the visbreaker coils. Charge to each of the two visbreaker heaters passes through a heating and then through a soaking section. Table 3 presents the normal operating conditions for the visbreaker coils. Flow in the heating section is through the upper roof, lower roof and down the side wall. In the soaker, flow is up through the side wall, into the lower roof and out the upper roof tubes. The oil leaving the furnace is normally at 350 psig and 865 F. The pressure is maintained by a slide valve near the inlet to the low pressure evaporator. The cracked oil flows through the slide valve into the low pressure evaporator. The properties of the visbreaker products are shown in Tables 4 and 5.

The visbreaking reaction products and the bottoms from the high pressure evaporator flow to the low pressure evaporators. Here the lighter materials are flashed overhead and the bottom products flow to the fuel oil vacuum tower.

The fuel oil vacuum tower is 11½ feet in diameter, 62½ feet in height, and has 2 bubble decks, 7 shower trays and 5 baffle decks. The tower is divided into three sections: The upper section serves to cool and condense the cracked vacuum distillate, the middle section serves to condense the visbreaker cycle stock, and the lower section serves as a flash section for the removal of the gas oils from the residual fuel oil. The tower normally operates at a vacuum of about 21 inches of mercury.

The overhead vapors are condensed in the overhead condenser and flow to the accumulator drum. Non-condensible vapors are disengaged in the overhead condensers and flow to the vacuum ejector system. Non-condensible vapors from the ejectors are discharged to a waste gas burner in one of the crude section heaters to eliminate emission of hydrocarbon vapor to the atmosphere.

The heavy cracked residuum leaves the bottom of the fuel oil vacuum tower at about 690 F. Gas oils are withdrawn from the bubble towers and fuel oil vacuum tower and as cutter stock join the residuum. The mixture is cooled to about 575 F. by heat exchange in reboilers in the thermal cracking unit. Additional cutter stock from tankage is added and the mixture cooled to about 235 F. in an open salt water cooling box. The cooled fuel oil then flows to bunker storage.

Decoking Visbreaker Heaters—The length of visbreaker runs between decoking are dependent on the refinery turnaround schedule as well as on cracking severity. Each section of the combination thermal cracking unit, including the visbreaker, is shut down for decoking and repairs at four-month intervals. The visbreaker is normally decoked once between turnarounds to give an average run of about 60 days. The decoking is done thermally unless internal tube measurements are to be made. Mechanical drilling is required to remove the last traces of coke from the tubes.

With the vacuum flashing unit on stream, the estimated change in overall refinery product distribution is as follows:

LPG, Gaso. and Solvents	+ 2.0%
Kerosine, Stove Oil, Diesel Oil	0
Fuel Oil	— 2.7
Asphalt, Fuel Gas, Loss	+ 0.6

These changes result from the increased recovery of heavy gas oil from the crude and its cracking at the Fluid catalytic cracking unit.

Original presentation was before the California Natural Gasoline Association's Fall Meeting, October, 1954.

ACKNOWLEDGMENT

The author wishes to thank Union Oil Co. of Calif. for permission to release the information on its refinery equipment. Also, the author wishes to acknowledge the assistance received from men in the Crude Distillation and Thermal Cracking departments and in the Process department at the Los Angeles Refinery.

TABLE 4
Properties of Visbreaker Product
Fixed Gas Analysis

COMPONENT	Mole Percent
$CO+N_2$	3.0
CO_2	2.3
H_2S	18.4
H_2	3.9
CH_4	41.8
C_2H_4	0.6
C_2H_6	16.0
C_3H_6	3.6
C_3H_8	10.4

TABLE 5
Properties of Visbreaker Product

Test	STREAM		
	425 F. E.P. Gaso.	425-725 F. Gas Oil	Crk'd Resid. 725 °F.+
Gravity, °API	53.1	24.5	1.4
Engler, °F. IBP	95	452	
10 Percent	163	500	
50 Percent	284	582	
90 Percent	384	718	
Max.	424	725	
Percent Rec.	97	93	
Viscosity SSU @ 210			3500
SSF @ 300			107
Sulfur, Wt. Percent	1.77		
Acid Solubility Vol. Percent	62.5		
Octane, MM Clear	67.0		
MM + 3 ml	72.6		
Res. Clear	73.0		
Res. + 3 ml	80.7		
Penetration @ 77 F.			11

Note: The products from visbreaking are not produced separately, but are mixed with the products from gas oil cracking in the thermal cracking unit.

When using pipe flanges . . .

Save Money With "O" Rings

. . . because an "O" ring flange requires less initial bolt tension to make a connection; less strain is carried over into the piping system.

E. C. Schuster and V. L. Rupe,
Service Pipe Line Company,
Tulsa, Oklahoma

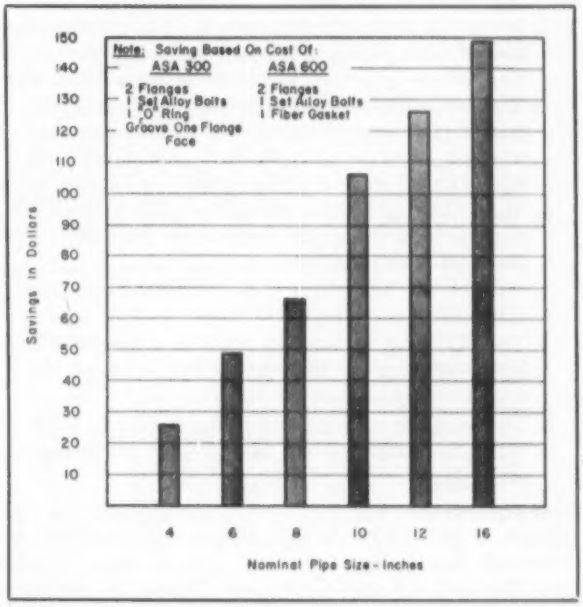
THE SYNTHETIC rubber "O" ring is one gasket type usually considered only for high pressures. Neither the "Code for Pressure Piping" nor the "Code for Unfired Pressure Vessels" include the "O" ring in their gasket-data tables. In fact, little data is available on the use of "O" rings in flanged joints.

Operating temperatures rarely exceed 100° F. in crude oil pipe line service. The welding-neck flange is the accepted standard for flanged joints. "O" rings and similar synthetic rubber pressure-seal gaskets have performed well in quick-opening scraper trap closures. These facts led us to believe that the "O" ring could be successfully and economically applied as a gasket in flanged joints.

To develop the feasibility of using "O" rings in place of standard flat gaskets, a two-phase program was initiated.

We first approached the problem theoretically by using the methods of calculation developed by E. O. Waters, D. B. Rossheim, D. B. Wesstrom and F. S. G. Williams in their paper "Formula for Stresses in Bolted Flanged Connections."[1] We calculated the theoretical stresses developed in the 12-inch ASA welding-neck flanged joint using an "O" ring gasket. Calculations were based on an allowable 17,500 psi flange stress and were made for ratings from ASA 150 through ASA 600. Our results showed that the ASA 300 series flanged-joint could be advanced safely to a working pressure rating of 1200 psi at 100° F. and remain within all API-ASME allowable stress ranges.

Satisfied from these results that our prognostication was correct, we undertook the second phase of our program. This consisted of a series of hydrostatic tests using a 12-inch series 300 welding-neck flange assembly modified to use an "O" ring gasket. In these tests, we evaluated the effects of internal pressure, bolt loads and flange-face design on the magnitude of stresses existing in the flanges and bolts.



GRAPH 1—Dollar Saving-ASA 300 flanged joint vs. ASA 600 flanged joint.

Our test results were gratifying in that they bore out our original hypothesis. Previously, we ran tests under similar conditions using a 12-inch ASA 300 flanged assembly and various regularly accepted flat gaskets. The performance of the "O" ring gasketed flanged joint was far superior to any previously tested. From the "O" ring test results, we concluded that:

1. By the use of an "O" ring, the ASA 300 raised or flat-face flanged joint, 12 inches and under in size, can be given a cold-service pressure rating

Save Money With "O" Rings . . .

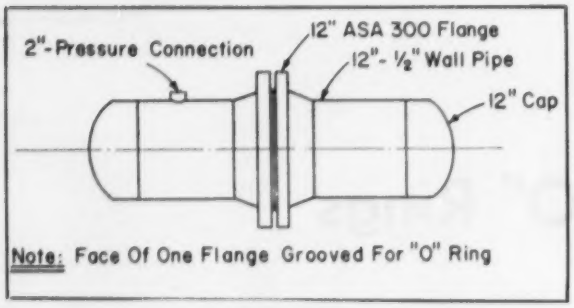


FIGURE 1

equal to the ASA 600 ring joint. (Theoretical calculations indicate that this uprating can apply through the 16-inch size. However, wo do not propose this until further tests on larger sizes are completed.)

2. With an "O" ring seal, only sufficient bolt load should be applied to mate the flange faces and to prevent relaxation from vibration, surges, etc. Excessive bolt loads are a detriment to the efficient operation of the joint. Alloy steel bolts should be used in all installations.
3. Because of lower over-all stress level in the flanges and adjacent piping, a flat-race flange is preferred. This allows a lighter flange to be used which is more commensurate with the design of the piping system. The heavier raised-face flanges now used transmit more of the thermal, vibrational and misalignment stresses to the weaker piping system.
4. The "O" ring groove should be placed as close as possible to the inside diameter of the flange. A practical limit would be:
   ID of the "O" ring groove = ID of flange plus two times diameter of "O" ring.
5. The "O" ring is easier to place in a fixed manifold joint than is the regular steel ring of the standard ring-joint.
6. The potential savings in up-rating flanges by using "O" rings make the use of this joint worth consideration.

Test Equipment. The tests were conducted with two test headers. First, a 12-inch unit, (Figure 1) was used to determine the ability of the "O" ring to effect a tight joint. Second, a 4-inch fabrication (Figure 2) was used to determine possible difficulties in installing a valve into a fixed manifold and its pressure-carrying ability after bolting up.

Test Procedure. The purpose of the tests was to evaluate:

1. Maximum operating pressures
2. Effects of initial bolt loads
3. Effects of raised-face on leakage pressure and bolt loads
4. Effects of flat-face on leakage pressure and bolt loads
5. Installation difficulties in a fixed manifold

Meet the

EDWIN C. SCHUSTER, engineer in the Research and Development Section at Service Pipe Line Company, received his B.S. degree in mechanical engineering from Marquette University in 1945. He joined the War Emergency Pipeline, Inc. immediately after graduation as an engineer under the pump station supervisor. In 1946 after operations of the Big and Little Inch pipe lines were suspended, he joined the faculty of Marquette University as an instructor in mechanical engineering. He became associated with Service in 1951. He is a registered professional engineer in Wisconsin.

Tests were run, using two raised-face flanges; a raised-face flanged header with a raised-face blind flange; two flat-face flanges; a flat-face flange and a flat-face blind.

To prevent undue distortion of the flanges, we held the maximum hydrostatic test pressure to approximately 3500 psi. On the last test, the test unit was carried to failure.

Two tests were run with the fixed manifold. In the first test, the distance between the flanges was held to the face-to-face dimension of a 4-inch ASA 300 raised-face valve. In the second test, this distance was increased ⅛-inch.

Analysis of test data. Table 1 shows a summary of test data. Stress values shown are based on the API-ASME code formulas for raised-face flanges. Since these formulae exclude all cases where there is any flange contact outside of the bolt circle, the stresses for flat-face flanges were calculated with formulae derived from the Rankine stress theory. Bolt stresses were calculated from deformation under load.

In the normal raised-face flange assembly using a flat gasket, high initial bolt loads are necessary to place the proper crush on the gasket for pressure seal. This results in high flange-stress levels. Table 1 shows the value of these bolt-loads taken from previous tests. With the application of hydrostatic pressure, the bolt load and flange stress reduce because of flange rotation. This flange rotation produces excessive stress in the adjacent pipe wall. With additional internal pressure, the bolt load again increases and reduces the compression in the gasket to a point where leakage occurs.

With an "O" ring replacing the flat gasket, essentially the same sequence occurs when hydrostatic pressure is applied, with the exception that the force required to

Authors

V. L. RUPE, who graduated in 1934 from Oklahoma A&M College with a B.S. degree in mechanical engineering, was with Reed Roller Bit Company eight years and in general machine and welding shop management and operation four years prior to joining Stanolind Pipe Line Company in 1947. In 1950 he was made engineer in the mechanical section of Service Pipe Line, formerly Stanolind. At present he is concerned with pump station design, economics of station machinery selection, specifications for and selection of machinery and mechanical construction materials.

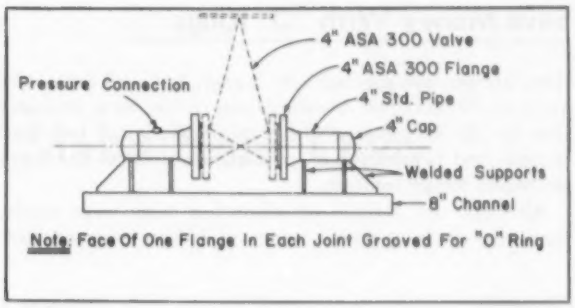


FIGURE 2

compress the "O" ring in the groove is negligible and initial bolt loads are small. This results in lower initial flange stresses, reduced flange rotation and lower stresses in the adjacent pipe walls. The seal is lost when the flanges separation is enough to extrude the "O" ring.

When flat-face flanges are used, a small initial bolt load is necessary to bring the flanges together and to prevent relaxation from vibration and surge. Additional initial bolt load is unnecessary and only raises the stress level of the unit. Since the flanges have metal-to-metal contact, the hydrostatic pressure tends to rotate the flange about its outer edge, but to a lesser degree than with raised-face flanges. This results in a continually increasing bolt and flange stress to the point of flange separation sufficient to cause leakage. In the flat-face flange assembly, leakage occurred at 4750 psi.

The flange material (SA 181-49 Grade II) has a minimum yield of 36,000 psi, and an allowable code design stress of 17,500 psi. Table I shows that all flat-face flange stresses are less than the allowable at a hydrostatic pressure of 2160 psi. At the same pressure, the raised-face flange stresses are all over the 17,500 psi allowable but below the minimum yield.

The bolt material (SA-193-49T-Grade B7) has a minimum yield of 105,000 psi and an allowable code design stress of 20,000 psi. At 2160 psi, the stress level of the bolts in the raised-face flange is close to the code allowable, but well below the yield point. In a flat-face flange

TABLE 1
Summary of Test Data
ASA 300 — 12" Flanges

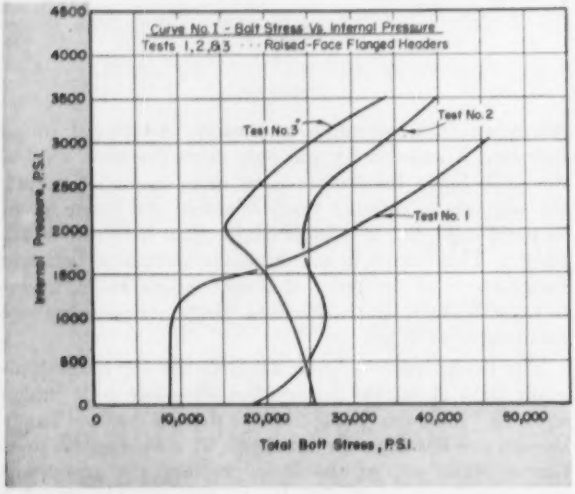
Test No.	TEST UNIT DESCRIPTION	Gasket Description	Initial[2] Bolt Stress	MAXIMUM CONDITIONS OBTAINED: Internal Pressure	Bolt Stress	Flange[3] Stress	Flange Condition	STRESS LEVEL AT 2160 Psi PRESSURE: Bolt Stress[5]	Flange Stress[6]
	Tests with "O" Ring Gaskets		**RAISED-FACE FLANGE**						
1	2-ASA 300 Flanges (Raised-Face)	"O" Ring (13.530" I.D.)	8,900	3,000	45,440	44,500	No Failure (Flange Face Distortion of .007")	28,450	32,280
2	2-ASA 300 Flanges (Raised-Face)	"O" Ring (13.530" I.D.)	18,260	3,450	39,080	39,820		21,550	25,390
3	2-ASA 300 Flanges (Raised-Face)	"O" Ring (13.530" I.D.)	25,560	3,650	36,920	38,310		14,220	18,050
4	ASA 300 Flange & Blind (Raised-Face)	"O" Ring (13.530" I.D.)	26,400	2,700	49,020	48,820		19,400	23,230
5	ASA 300 Flange & Blind (Raised Face)	"O" Ring (13.530" I.D.)	26,000	3,450	38,200	39,060		17,240	21,080
			FLAT-FACE FLANGE						
6	2-ASA 300 Flanges (Flat-Face)[1]	"O" Ring (13.530" I.D.)	10,200	3,500	51,800	17,090	No Failure (No measurable Flange Face Distortion)	36,000	11,880
7	2-ASA 300 Flanges (Flat-Face)[1]	"O" Ring (13.530" I.D.)	26,900	3,500	62,000	20,460		41,520	13,700
8	ASA 300 Flange & Blind (Flat-Face)	"O" Ring (13.530" I.D.)	11,360	3,500	49,700	16,400		34,520	11,390 [4]
9	ASA 300 Flange & Blind (Flat-Face)	"O" Ring (13.530" I.D.)	24,200	3,500	66,740	22,020		44,520	14,690
10	2-ASA 300 Flanges (Flat-Face)	"O" Ring (13.530" I.D.)	10,940	4,750	Over 50,000	Over 17,000	Leakage	32,890	10,890
			RAISED-FACE FLANGE						
Average of 8 Tests with ASA 300 Flange & Blind (Raised-Face)		Spirotallic with Retainer	.....	1,480	52,000	47,200	Leakage	.....	.....
Average of 2 Tests with ASA 300 Flange & Blind (Raised Face)		Compressed Fiber	.....	1,200	58,000	52,000	Leakage	.....	.....

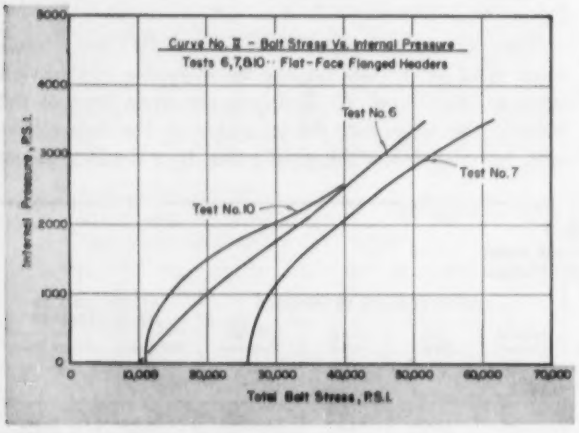
[1] Flat-Face Flanges are standard Flanges with the Raised-Face removed.
[2] All bolt stresses are based on measured bolt elongation.
[3] All Raised-Face flange stresses are based on API-ASME Code 1951.
[4] All Flat-Face flange stresses are based on Ranking Theory as proposed in "Piping Handbook—1945".
[5] 4140 Bolt: Minimum yield 105,000 psi—API-ASME design allowable 20,000 psi.
[6] Flange: Minimum yield 36,000 psi.—API-ASME design allowable 17,500 psi.

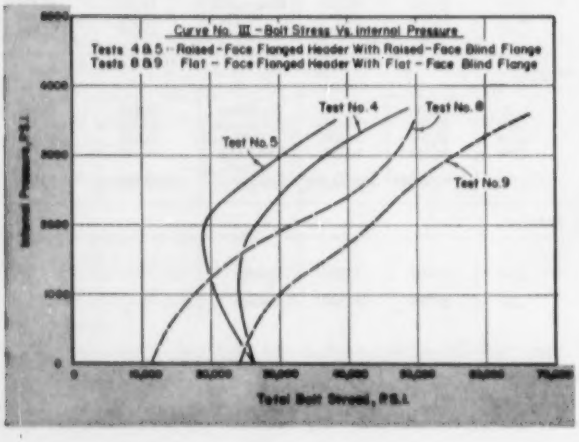
these stresses are substantially higher, but well below the yield of 105,000 psi. A comparison of the data indicates that the flat-face flange with a minimum initial bolt load is preferred because of its over-all lower stress level and decreased flange rotation.

Although no fatigue or distortion tests were made, literature discloses that a series of fatigue tests on full-sized assemblies permitted the following conclusions:[2]

1. Under unusual, severe bending stresses, raised-face flange assemblies do not fail in the flange proper, by fracture of the bolts, or by leakage across the joint face.
2. Failure occurs almost always in the pipe adjacent to the flange and in rare instances across an unusually weak attachment weld.
3. The endurance strength of a welding-neck flange assembly is equivalent to that of a butt-welded joint between two pieces of pipe.




Curve No. II - Bolt Stress Vs. Internal Pressure
Tests 6, 7, & 10 · · · Flat-Face Flanged Headers
Test No. 6
Test No. 7
Test No. 10
Internal Pressure, P.S.I.
Total Bolt Stress, P.S.I.


Curve No. III - Bolt Stress Vs. Internal Pressure
Tests 4 & 5 · · · Raised-Face Flanged Header With Raised-Face Blind Flange
Tests 8 & 9 · · · Flat-Face Flanged Header With Flat-Face Blind Flange
Test No. 4
Test No. 8
Test No. 5
Test No. 9
Total Bolt Stress, P.S.I.

Economics. The comparative cost of ASA 300 and ASA 600 raised face flanges is:

Size	COST PER FLANGE ASA 300	ASA 600	Saving
10	$21	$ 71	$50
12	37	96	59
16	92	161	69

The average cost of machining the "O" ring groove in one flange of a joint is about $3 in sizes 10-inch through 16-inch. Bar graph I shows the savings possible if ASA 300 flanges are used rather than ASA 600.

Closure. We consider it safe and practical to uprate flanged joints in cold service by using "O" rings. We know that it is economical.

"O" rings of synthetic materials that are resistant to hydrocarbons and age deterioration are now available.

We recognize certain limitations. For instance, this joint will not be satisfactory where insulating flanges are required.

We do not consider the fire hazard as serious, since there remains a metal-to-metal secondary-seal against excessive leakage.

In fact, we venture to say that, someday soon, manufacturers' standards and governing codes will recognize this type of joint for cold service. This should result in a new flange design of light section and small diameter—pound-for-pound twice as efficient as the present standard.

ACKNOWLEDGMENTS

The authors wish to acknowledge the initial work done on this development by Charles Wheatley of Tulsa as well as the assistance of their fellow employes in conducting these tests.

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[1] "Formula for Stresses in Bolted Flanged Connections," by E. O. Waters, D. B. Rossheim, D. B. Wesstrom, and F. S. G. Williams, *ASME Transactions* (1937).

[2] "Fatigue Tests on Flanged Assemblies," by A. R. C. Markl and H. H. George, *ASME Transactions* (1949).

NOMOGRAMS . . . Make Your Own

Part 1. How to prepare various types of scales

Part 2. Laying out the nomogram

Part 3. How to prepare different types of nomograms

Francis W. Winn,
Fractionation Research, Inc.,
Alhambra, California

A SCALE is a particular visual means by which a function of a variable may be represented just as are the Y-axis and X-axis of a coordinate plot. The scale shown in Figure 1b in Part 1 of this series is a uniform scale and represents the equation,

$$f(X) = X$$

A more complete description of the scale which shows the limits involved is

$$f(X)\Big]_2^7 = X\Big]_2^7$$

The scale in Figure 2a in Part 1 of this series is a logarithmic scale and represents,

$$f(X)\Big]_2^7 = \text{Log } X\Big]_{\log 2}^{\log 7}$$

Sometimes it is necessary to construct a scale which is not available as the ordinate or abscissa in convenient graphical form. As an example it is desired to construct a scale for the function:

$$f(X)\Big]_3^7 = X^2\Big]_9^{49}$$

The quickest method of doing this involves plotting the function on graph paper in a manner such that the height of the ordinate axis is equal to the desired length of the scale stem. The procedure is as follows:

1. Draw the scale stem to the desired length and calibrate with the terminal values of the *variable;* i.e., 3 and 7 for the example being illustrated. See Figure 3a.

2. Attach a sheet of arithmetic graph paper to the board and calibrate the vertical lines to include the terminal values of the *function;* i.e., 9 to 49 in Figure 3a. Project the terminal values of the variable from the scale stem to corresponding values of the function represented by vertical lines of the graph paper. Connect the two points of intersection with a straight transversal.

3. Prepare a table showing several values of the variable and corresponding values of the function. Values for the example are shown below:

Variable X	Function X^2
3	9
4	16
5	25
6	36
7	49

4. Attach a second sheet of graph paper adjacent to that from Step 2. Calibrate the vertical lines to include the terminal values of the *variable;* i.e., 3 to 7 in Figure 3b.

5. Each tabulated value of the function is located on the transversal from Step 2 and this point is projected horizontally to that vertical line of the graph paper from Step 4 which represents the corresponding value of the variable. The points of intersection are circled as otherwise marked.

6. A smooth curve is drawn carefully through the circled points. The more nearly this curve is a straight line, the more accurate will be the final result. The choice of the graph paper in Step 4 determines whether the curve is near-linear or not. The intersections of this curve with the verticals are projected horizontally to the scale stem resulting in the desired scale function as illustrated in Figure 3b.

It would of course be possible to accomplish the construction of such a scale using only one sheet of graph paper rather than two. Two are used in the illustration to prevent undue confusion.

Do Most Nomograms Consist of Two Parallel Straight Scales? Many equations and empirical relationships can be plotted on arithmetical, log-log, or semilog rectangular coordinate paper as straight lines. Or, it may be necessary to use an empirical abscissa and/or ordinate, such as on the ASTM viscosity-temperature chart. If it is possible to obtain the desired linear relation using a set of straight parallel abscissa lines, a set of straight parallel ordinate lines and a set of parameter lines which are straight

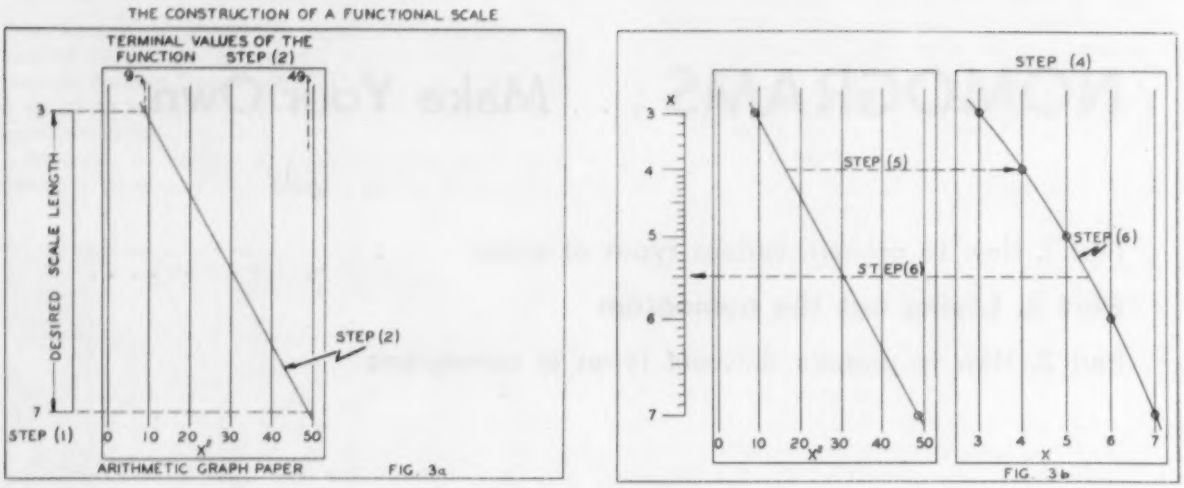


FIGURE 3—How to construct a functional scale.

but not necessarily parallel, a nomogram can be constructed.

The *straight scale stems* of a nomogram which represent *families of parallel lines* of a coordinate plot are always themselves *parallel.* Thus most nomograms consist of at least two *parallel* straight scale *stems,* one representing the abscissa and the other representing the ordinate of the equivalent rectilinear coordinate plot. Use of this fact simplifies the lay-out and construction of a nomogram considerably.

What About the Relative Direction of the Scales of a Nomogram? If a linear coordinate plot consisting of a family of parallel straight ordinate lines, a family of parallel straight abscissa lines and a family of straight parameter lines is transformed into a nomogram, the result will always consist of two straight parallel scales graduated to represent the ordinate and abscissa and a third scale, not necessarily straight or parallel, graduated to represent the parameter or third variable. For simplicity the nomographic scales which represent these three variables, namely, the abscissa, ordinate and parameter, will be referred to as the X-scale, Y-scale and Z-scale, respectively.

The direction of a scale is loosely that which shows increasing values of the variable calibrated along it. The parallel X- and Y-scales of a nomogram can be calibrated to be of either the same or opposite directions. The choice determines the location of the Z-scale. The Z-scale which corresponds to a family of lines having a *positive* slope in coordinate chart form will always fall between the X- and Y- scales provided the X- and Y-scales are of *opposite* directions. The Z-scale which corresponds to a family of lines having a *negative* slope will always fall between the X- and Y-scales provided they are of the *same* direction. The Z-scale will fall outside if the relative directions of X- and Y-scales are reversed from that stated above.

The Layout of a Nomogram. The distance between the two straight parallel scales of which most nomograms are comprised can be established arbitrarily, as can the lengths of the two scales. They are usually arranged so that the nomogram takes on a rectangular outline of proportions which can be enlarged or reduced, by photographic offset printing processes, to utilize to maximum advantage the space available on the standard sizes of paper. Taking the binding margin into consideration, the most desirable shape for size 8½ by 11 inches or 11 by 17 inches paper is a rectangle having a length which is 1.5 times its width.

Choice of Nomographic Form. There are three basic nomographic forms which correspond to each rectilinear coordinate plot. Figure 4 shows the schematic forms for the equation $y = x + z$. The distinguishing feature about these is the difference in the center scale, the first, second and third columns having center scales of Z, X and Y, respectively.

Each basic form has three additional variations. The second set of the nomograms of Figure 4 is the inverted form of the first line. The third and fourth are other variations as indicated.

The most desirable form of presentation is dicated by the following considerations:

1. The scales should be of equal length.
2. The dependent variable, if specified, should be the center scale.
3. The direction of the scales should be upward.

Obviously it is not always possible to satisfy these conditions. Assuming that Z were the dependent variable, forms a or j would be the more desirable for the particular equation sketched in Figure 4.

The arrangement of the X- and Y-scales which causes Z to be the center scale is the most satisfactory from an ease of construction viewpoint.

The Method of Location of the Z-Scale Stem. The exact position of any point on the Z-scale can be established by the intersection of two or more temporary construction lines drawn through the previously established X- and Y-scales at values which are the "coordinates" of the

corresponding Z-line on the coordinate plot. The Z-scale will be parallel to the X and Y scales if the coordinate plot is a family of parallel lines. For such families of lines, the location of one point of the Z-stem also fixes the remainder of the Z-stem since a straight line through the point and parallel to the X- and Y-axes will be the Z-stem.

The only other case where a straight Z-stem is obtained is for a family of lines which converge to a point on the coordinate plot. The Z-stem corresponding to a family of converging lines will fall on a straight line drawn through the X- and Y-scales at the values which are the coordinates of the point of convergence.

The location of the Z-scale stem for other than the two cases just discussed is done by: (1) finding a number of points at various values of Z throughout its range, using the method of intersecting construction lines through pairs of coordinates, and (2) drawing a smooth curve through these points.

The Graduation of the Z Scale Stem. Having located the Z-scale stem, there remains its graduation and calibration. For a Z-stem which is straight the following procedure is suggested.

1. Use intersecting temporary construction lines to locate points along the Z-stem corresponding to several values of Z which cover its range;

2. Turn the paper so that the Z-stem is perpendicular to the T-square;

3. Fasten a sheet of graph paper to the drawing board adjacent to the Z-stem and calibrate the vertical lines to include the range of Z-values to be covered;

4. Project the Z-points from step (1) to the corresponding vertical lines of the graph paper and circle the points of intersection so obtained;

5. Draw a smooth curve through the circled points—the choice in step (4) of the graph paper which gives the least curvature in this step will result in the greatest accuracy;

6. Project the intersections of the curve with the vertical lines of the graph paper back to the Z-stem as graduation marks; and,

7. Calibrate the axis and add the proper legend.

For a Z-stem which is not straight, the above procedure can be followed for short segments to locate where the graduation strokes join the stem. The strokes should be drawn perpendicular to stem.

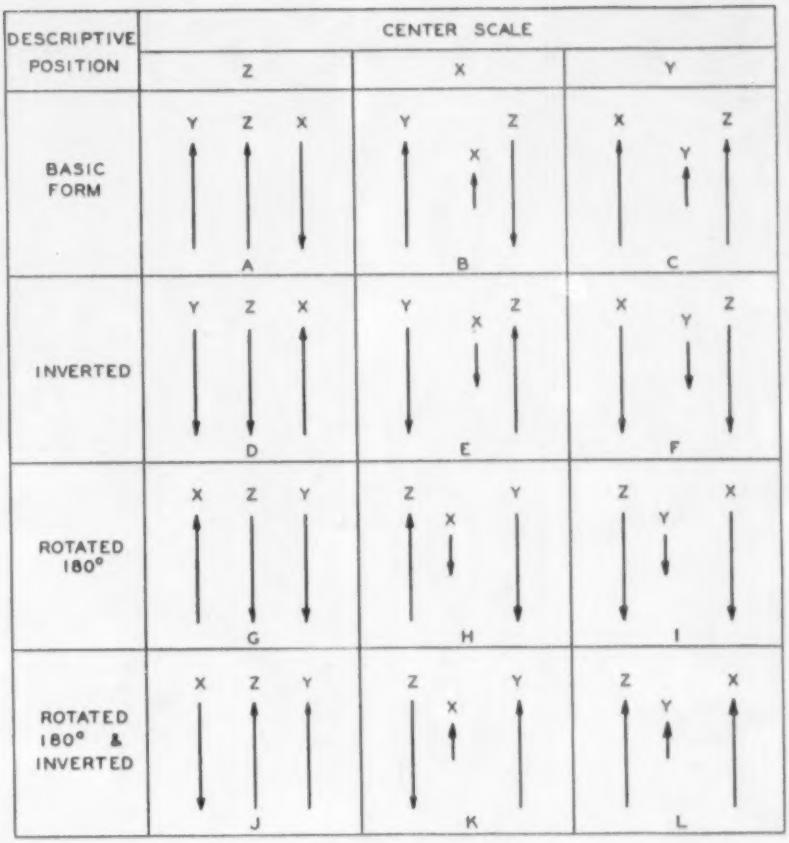
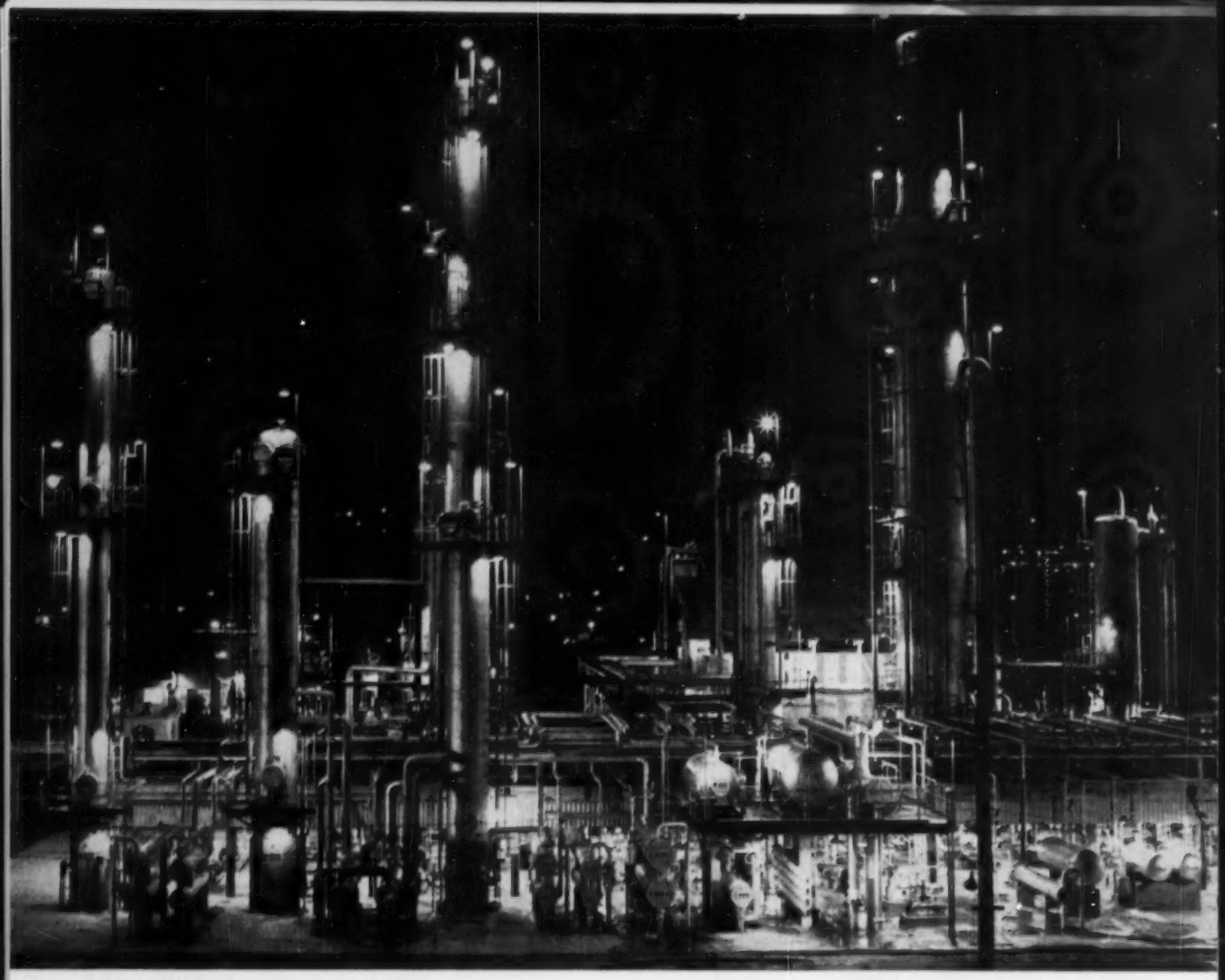


FIGURE 4—The different forms of parallel nomograms.

The Significance of the Slope of a Line on a Coordinate Plot. The slope of a Z-line on a coordinate plot affects the location of the corresponding nomographic Z-point with respect to the X- and Y-scales of the nomogram. The distance from the Y-scale to the nomographic point, divided by the distance from the point to the X-scale, for nomograms composed of parallel X- and Y-scales, is proportional to the slope of the coordinate Z-line; i.e., to the tangent of the angle subtended by the coordinate Z-line with X-axis of the coordinate plot. Thus for a coordinate Z line which has a high slope, the corresponding nomographic Z-point will be close to the X-scale; for one of low slope it will be near the Y-scale. The nomographic Z-points which correspond to coordinate Z-lines having slopes of infinity and zero will fall on the X-scale and Y-scale, respectively. See Example 3. This information is useful in the preliminary sketching of a nomogram which should preceed the actual construction. It is also useful in deriving the general nature of the equations which a given nomogram represents.

The Significance of the Intercepts of a Line on a Coordinate Plot. The intercept of a Z-line with the ordinate on a coordinate plot also affects the position of the corresponding nomographic point. A nomographic Z-point will fall on a line drawn between $X = O$ on the X-scale and that value on the Y-scale corresponding to the Y-intercept. Likewise the point also will fall on a line drawn between $Y = O$ on the Y-scale and that value on the X-scale equal to the X-intercept. Since the Y- and X-intercepts of a line are two sets of coordinates of the line, (O,Y_1) and (X_1,O) respectively, they may be used to establish the nomographic Z-point equivalent of the coordinate Z-line.

End of Part 2. Part 3 will appear in a future issue of the REFINER.



This refinery includes crude topping, thermal cracking and vis breaking. It is expected to satisfy about 60 percent of the local demand for gasoline.

New Refinery Serves Rio de Janeiro

Privately owned plant operating under government control.

THE 10,000 barrel-per-stream-day Manguinhos Refinery, in the Federal District of Brazil, usually known as Rio de Janeiro, was placed on stream in December, 1954. A private Brazilian group financed the plant and it is being operated as a private enterprise under Brazilian government control as required by the "Petrobras" law. This situation resulted from the granting of a concession by the Government for construction prior to the enactment of "Petrobras."

Construction was accomplished in about eight months using, at the peak, a thousand men. Engineering and procurement was performed by The M. W. Kellogg Company with construction assistance by Kellogg's subsidiary, Kellogg Pan American. The over-all cost is reported to have been approximately $12 million. The refining process is topping, thermal cracking and vis breaking.

Venezuelan crude is delivered to the refinery by a 16-inch pipe line from docks about 1¾ miles away. The design thruput is 10,000 barrels per stream day for yields of 6842 barrels gasoline, 2737 barrels fuel oil, 465 barrels LPG, and 7751 pounds per hour fuel gas. This production is expected to fill about 60 percent of the local demand for gasoline and 30 percent of the fuel oil needs. Local refining instead of importation is expected to save the country some $5.5 million yearly.

The utility facilities provided include two 40,500 pounds per hour steam generators, electrical power supply 3500 KVA at 25 KV, and a 10,000 gpm sea water circulating system. Tankage capacity is 440,000 barrels including crude, intermediate, and finished products. ##

Gas Conditioning Today

What the problems are and how they are being solved.

Glycol amine plant—The most serious problems are chemical loss, corrosion, and steam consumption.

Part 1. Particulate matter removal and gas purification
Part 2. Dehydration

A. L. Kohl and F. C. Riesenfeld,
The Fluor Corporation, Ltd., Los Angeles

HERE ARE some of the recent developments in gas conditioning technology. No detailed description will be presented of the processes and equipment in common use, as these are well known and have been described in many articles which have been published in the technical journals. To further confine the scope of this article, the subject matter has been limited to the fields of particulate matter removal, gas purification and dehydration.

Removal of Particulate Matter. Particulate matter occurring in gas streams may be either in the form of solid particles as, for example, iron oxide or iron sulfide, or liquid droplets such as lubricating oil or liquid entrainment from an absorber. The liquid droplets are generally removed by baffle, metal wire mesh, or cyclone-type eliminators, all of which depend upon momentum to cause the liquid droplets to impinge against fibers or surfaces.

Solid particles may also be removed by the use of the impingement or cyclonic principle. However, the problem is more difficult because the solids do not coalesce upon striking a surface, nor can they be drained from the elements continuously as can liquids. Because of these considerations, wet type scrubbers are frequently used for removing solid particulates. In these, a liquid phase is deliberately added to the gas stream to wet the solid particles and render them more easily removable by practical eliminator systems. In one advanced gas cleaner design, a Venturi is used to inject and atomize the wash liquid. This provides a dispersion of very fine liquid droplets onto which the solid particles can impinge. The atomizing section of this cleaner is followed by a mist eliminator section made up of a high load element for removing the bulk of the liquid and a high efficiency element for removing the last traces.

The use of glass fiber mats for removing very small solid particles has also been reported.[1] These glass fiber filters are very efficient for removing solid particles measuring as low as one micron in diameter. However, the particles remain in the glass fiber mat which must be replaced at intervals. Liquid droplets are also removed by the glass fiber filter. However, when a certain point of saturation is reached, liquid is re-entrained and blown through the filter by the gas stream.

A major area of research in the field of gas cleaning is the development of techniques for evaluating the efficiency of the particle removing devices. One of the major efforts in this field is being conducted by Arthur D. Little, Inc., under the auspices of the American Gas Association, and will not be discussed in this paper. A technique for obtaining a representative gas sample and determining the quantity of particulate matter in the sample has been developed by The Fluor Corporation, Ltd., and recently tested commercially in the field.[2]

A special nozzle is inserted into the gas stream so that minimum turbulence is produced and a small stream of the gas is drawn through this nozzle at the same flowing velocity as the main gas stream adjacent to it. The sample stream is then filtered through a mat containing one micron diameter glass fibers at the full system pressure (up to 1000 pounds per square inch) and metered. By noting the weight increase in the filter and by visual examination, an accurate evaluation can be made of the particulate matter concentration at the gas stream sample point.

There is a growing trend for more complete removal of all particles from gas streams. This is the result of the desire for maintaining maximum pipe line efficiency and the development of gas burning devices which require extremely pure gas.

Gas Purification. The treatment of gas for the removal of hydrogen sulfide and carbon dioxide has been discussed very extensively in recent literature. The processes most widely employed utilize alkanolamines, primarily monoethanolamine (MEA) in aqueous solutions and in combination with glycols.[3, 4]

No exact figures are available on the total volume of pipe line gas treated with amine solutions. Approximately 1.5 billion cubic feet per day are treated with glycol amine solutions, and the total is undoubtedly several billion cubic feet per day. Rather than describe the general features of the amine processes, a discussion of the major problems which have been encountered and their attempted solutions will be presented.

Gas Conditioning Today . . .

The most serious problems in the amine processes are (1) loss of chemicals either by vaporization, entrainment or deterioration, (2) corrosion, and (3) steam consumption.

Chemical Losses. Loss of solvent by entrainment or vaporization is undesirable, not only because of the cost of the chemicals but also because of the contamination of pipe lines by liquids deposited on the line walls, resulting in marked decrease of line efficiency.

Entrainment losses are caused either by inefficient mist extraction or by foaming and subsequent carryover of the solution into the pipe line. As the technology of mist elimination from gas streams advances, the problem of entrainmet will be reduced. At preset, it appears that the so-called wire meshes are the most efficient means of preventing entrainment of liquid droplets. In most cases it has been found practical to install wire mesh mats of 4 or 8 inch depth either in the top of the treating plant contactors or in a separate mist eliminator vessel.[5]

Foaming, which has been observed in many plants using aqueous amine solutions, can usually be controlled successfully by the addition of foam inhibitors. Most widely used foam inhibitors are either silicones or high boiling alcohols such as oleyl alcohol or octylphenoxyethanol. These are generally added in concentrations of 10-15 parts per million. It is of interest to note that diethylene and triethylene glycol are very effective foam depressants, and therefore foaming problems are not encountered in plants using glycol amine solutions.

Chemical losses due to vaporization can be combated by various methods. Probably the most simple procedure consists of washing the purified gas with water using either a few trays at the top of the contactor or a separate vessel. Experiments conducted in the Fluor laboratories have indicated that approximately 40-50 percent of the vaporized amine is removed per tray, and it is seen that three or four trays will provide an effective vapor recovery system. Another scheme which provides recovery of vaporized amine without saturating the gas with water has been described by McCartney.[6] This consists of circulating a stream of glycol over the top trays of the contactor, withdrawing this stream and removing the amine from the glycol in a small reboiler. The vapors from this reboiler are fed to the main regenerator, and thus the amine is recombined with the main solution stream.

Amine vapors can be removed from the gas stream by intimate contact with small amounts of CO_2. Several years ago, it was discovered that if sufficient contact is allowed, MEA and CO_2 react in the vapor phase forming the hydroxyethyl ammonium salt of hydroxyethyl carbamic acid which, because of its low vapor pressure, condenses. Simple laboratory experiments indicated that small glass wool mist extractors installed in a line which carries gas containing MEA vapor and small amounts of CO_2 will remove approximately 50 percent of the amine as carbamate. Subsequent field tests showed that the liquid recovered in mist eliminators containing wire mesh located downstream of amine contactors consisted to an appreciable degree of carbamate, indicating that the wire mesh did not only function as an effective detrainment element but also as a promoter for the reaction between MEA and CO_2.

Another approach to the problem has been taken by the El Paso Natural gas Company and pioneered into large scale field application.[7,8] This method consisted of adsorption of amine and glycol vapors on Bauxite and subsequent regeneration of the saturated Bauxite bed by heating and steam addition. Laboratory investigations conducted at Fluor in cooperation with El Paso Natural Gas Company showed that Bauxite will adsorb amine and glycol vapors considerably beyond its saturation point with respect to water. Since, in many cases, the gas fed to the Bauxite beds has been dehydrated previously with glycol amine solutions and no additional water removal is necessary, advantage can be taken of this phenomenon, and relatively high capacities of the Bauxite for amine and glycol vapors can be realized. The laboratory tests showed that the Bauxite could adsorb MEA to the extent of approximately 3.0 percent of its weight before detectable amounts passed through the bed. At present, several units of this type are in operation in the pipe line system of El Paso Natural Gas Company.

Meet the

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Vaporization losses can also be minimized by the use of amines and glycols of extremely low vapor pressure. In some operations, diethanolamine (DEA) is being used successfully, and triethanolamine (TEA) has also been employed. However, hydrogen sulfide removal is much less complete when DEA and TEA are used, especially at relatively low pressures. A rather new development which will be discussed later is the use of methyldiethanolamine (MDEA) as a selective solvent for H_2S in the presence of CO_2.[9] This amine has a very low vapor pressure, and therefore chemical losses due to vaporization are minimized. Finally, the use of a compound combining the properties of a primary amine and a glycol, hydroxy amine ethyl ether, which has an extremely low vapor pressure, has been recently disclosed.[10] Pilot plant tests of this material by Fluor have indicated that very excellent H_2S and CO_2 removal can be obtained with simultaneous dehydration, if desired.

Solution deterioration, with attendant losses in solvent, may occur from several sources. Accumulation of solids such as iron sulfide, dust and carbon-

Authors

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aceous tarry materials will decrease the efficiency of the solution primarily because of viscosity increase. These materials can be removed by filtration or settling.

Another type of solution deterioration is caused by thermal or chemical deterioration of the amine or glycol. In general, MEA and DEA are thermally stable at the temperatures commonly used in the regeneration step. There are no cases known to the authors where aqueous or glycol amine solutions were subject to thermal decomposition. The presence of oxygen in the system may cause oxidative degradation of both the amine and the glycol. The chemistry of oxidation of amines in the system is not fully established, and it is very well possible that the mechanism is such that the oxygen reacts first with the hydrogen sulfide forming free sulfur, which upon heating reacts with the amine forming dithiocarbamates and thioureas which cannot be reconverted into the free amine by application of heat. Glycol appears to be subject to oxidative degradation, resulting in the formation of acids.[11] The reaction for DEG has been studied in detail by the Dow Chemical Company. This work has shown that formic acid is one of the decomposition products and the effect of pH is fairly sharp; the oxidation rate is markedly lowered at pH's of 6 and higher.[12]

The obvious remedy for this difficulty is complete exclusion of oxygen from the system, although the use of oxidation inhibitors has shown promise with glycols. In many plants, entry of oxygen into the solution is prevented by providing inert gas blankets for storage tanks and other locations where the solution may be exposed to the atmosphere. In order to prevent oxygen entering the system with the gas, the gathering systems should be maintained at positive pressure.

Probably the most serious cause of solution deterioration is the chemical reaction of the amine with certain constituents of the gas to form compounds from which the amine cannot be regenerated by application of heat. A great variety of contaminants reactive with amines have been found in gass, including formic, acetic and butyric acid, and sulfur compounds such as COS. The simultaneous presence of oxygen and H_2S in the gas will lead to the formation of thiosulfuric acid in aqueous solutions which will react with the amines. The salts formed by the amine with organic and thiosulfuric acids can be decomposed by the addition of a strong alkali such as sodium carbonate or sodium hydroxide, liberating the amine. COS, however, forms a more complex compound with MEA which cannot be regenerated by known techniques. DEA absorbs COS to some extent, but the DEA is recoverable almost quantitatively in the regeneration operation. The COS, however, may be partially hydrolyzed to H_2S and CO_2 in the process. TEA, being a tertiary amine, will not react with COS.

Extensive work conducted by Carbide and Carbon Chemicals Company has clarified the reaction of CO_2 with amines. It appears, on the basis of this work, that at elevated temperatures CO_2 reacts with MEA and DEA to form compounds which cannot be regenerated by heat and which, because of their low vapor pressure, will accumulate in the solution. Two end products of the reaction, in equilibrium with each other, have been isolated and identified.[13]

Heavy high boiling compounds, as well as sludge, can be removed from the solutions by distillation of a small side stream. In aqueous solutions this is effected by semi-continuous steam distillation with the addition of alkali, if necessary, to liberate the amine from acid salts. Glycol amine solutions are distilled under reduced pressure, approximately 10-inch Hg. and temperatures from 300-375° F. Several of these stills are in operation and are giving very satisfactory performance. The effectiveness of the distillation can be controlled by comparison of solution analyses for primary amine nitrogen, total alkalinity, and total nitrogen.

Corrosion. One of the most serious problems in the operation of amine gas treating plants is corrosion of certain pieces of the processing equipment. Very extensive studies have been conducted during the past five years on this subject;[14,15,16] and the corrosion mechanism has been clarified considerably. It was found that the prime reason for corrosion of carbon steel which is most commonly used in the construction of gas treating plants is the presence of rather high concentrations of H_2S and CO_2 in the treating solutions at high temperatures. The ratio of CO_2 to H_2S appears to have some influence on the severity of the corrosive attack although no exact correlation has as yet been developed. In addition, the presence of small amounts of oxygen appears to aggravate corrosion considerably. Finally, certain decomposition products of the amines and glycols also have corrosive effects.

There are several practices which can be observed in the operation of amine treating plants which will minimize corrosive attack. The temperature of the solution in the reboiler and the temperature of the steam used in the reboiler should be kept as low as possible. Use of high temperature heat-carrying media such as oil should definitely be avoided. Pressure regeneration of aqueous solutions has proved to result in severe corrosion of reboiler tubes, and it is therefore good practice to maintain the lowest possible pressure on the reboilers. In order to prevent oxygen from entering the system, it is advisable to maintain blankets of inert gas over all parts of the equipment which could be exposed to the atmosphere and to insure

positive pressure on the suction side of all pumps.

Furthermore, continuous removal of suspended solids by filtration and of decomposition products by distillation of side streams will generally help to reduce corrosion. It should be realized that plant design changes to minimize corrosion are usually accompanied by increased operating and investment costs and are therefore limited by these factors.

For example, it would be desirable to circulate a considerable excess of solution in order to maintain a low acid gas concentration in the rich solution entering the regeneration stage. This will, of course, result in larger equipment and additional utility consumption. Another approach to the alleviation of corrosion is the use of more expensive corrosion resistant alloys in place of carbon steel. Quite recently, the use of corrosion inhibitors has also been tried and some success reported in aqueous systems.[17]

It should be mentioned that proper practice in cleaning of the plant equipment can influence corrosion quite critically. The use of acid, even if inhibited, for the removal of iron sulfide and other sludge deposits can lead to increased corrosion by exposing bare metal surface to the attack. Field practice has shown that, in most cases, plants can be cleaned quite successfully by employing a good detergent combined with a sequestering agent.[18]

In some cases, it is necessary to boil the cleaning solution for several hours, especially in major vessels such as contactors and regenerators, and in plants where very severe fouling occurs it may even be necessary to remove the deposits mechanically.

The following discussion on specific corrosion problems will be presented in the sequence of the solution flow through the system.

With the exception of one case where stress corrosion cracking was reported in a plant using an aqueous MEA solution,[19] no corrosion of contactors is known to the authors. It was found that stress relieving of the vessel eliminated corrosion entirely.

Considerable corrosion of carbon steel heat exchanger tubes has been experienced in both aqueous and glycol amine systems. In aqueous systems, the attack has been found both on the rich and lean solution sides and has normally been most severe in the hottest pass. In glycol amine systems, the most severe corrosion has generally been found on the rich solution side of the hottest heat exchanger pass. There are no cases known where significant corrosion has occurred on carbon steel exchanger shells.

Extensive studies of this problem[14,15,16,20] have shown that certain design changes such as maintaining low velocities, placing the rich solution in the tubes, and maintaining pressure on the heat exchangers do reduce corrosive attack. Furthermore, the suitability of aluminum for glycol amine plant service has been demonstrated by field experience extending over a period of several years.

It should be understood that aluminum is not entirely resistant to corrosive attack; however, sufficiently long service life has been realized to make the use of this material very economical. One problem which has been encountered in the use of aluminum heat exchanger tubes is the so-called baffle cutting caused by vibration of the tubes in the baffle holes. As a result of field experience, it has been considered that the cutting action can be reduced by removing evolved gas from the system ahead of each exchanger.

The use of aluminum baffles instead of carbon steel was not found to reduce the baffle cutting; however, some experiments conducted recently indicate that the surface of the aluminum tubes can be hardened by anodizing to such an extent that very little baffle cutting will occur.[20] Steel alloys containing 5 percent chromium and ½ percent molybdenum are also very resistant to corrosive attack in glycol amine systems. The choice, however, is with aluminum, primarily for economic reasons. Very recent information indicates that aluminum heat exchangers are satisfactory in aqueous amine service provided a sufficient residual of CO_2 is left in the lean solution.

Laboratory experiments[11] have shown that acid gases and a minimum concentration of 40 percent glycol protect aluminum against the alkaline attack exerted by aqueous lean amine solutions. A considerable number of alloys were tested for aqueous amine service and it appears that the low chromium alloys and monel do not offer any advantages over carbon steel. The most resistant materials for heat exchanger tubes in aqueous systems seem to be Types 304 and 316 stainless steel.

The stripping columns of several plants using both glycol amine and aqueous amine solutions have been subject to corrosion. Several cases of stress corrosion cracking have been reported in aqueous plants.[19] Here again, the difficulty can be eliminated by stress relieving of the vessel. Corrosion of amine plant stripping columns has ranged from very mild to extremely severe and has been found both in the liquid and vapor space as well as in different locations of the vessel.

Remedies tried include lining of the vessel with stainless steel, insertion of a partial aluminum liner in the most critical area, use of aluminum trays and bubble caps in certain locations, use of ceramic packing, and concrete coating of the vessel walls.[21] Stainless steel lining and use of stainless steel trays, as well as concrete coating of the stripping column walls, have been found to be successful in aqueous amine systems. However, these measures have not been necessary in glycol amine plants. Insertion of an aluminum liner covering a few trays in the vicinity of the solution feed point, and use of aluminum trays and bubble caps in that area have been a successful solution for corrosion problems in several glycol amine installations.

Corrosion has occurred in various degrees on reboiler tubes in both aqueous and glycol amine plants, although it appears that the reboilers of aqueous amine plants are more susceptible to corrosion than in glycol amine systems. This can be explained by the fact that a considerable amount of acid gas stripping is accomplished in the reboilers of aqueous amine plants, while in glycol amine systems the solution is stripped practically free of acid gas in the stripping column.

The beneficial effect of low acid gas level apparently more than compensates for the effect of the higher temperatures employed in glycol amine reboilers. Very extensive studies of the usefulness of different alloys in reboiler service have shown that Types 304 and 316 stainless steel are quite resistant to corrosion by aqueous amine solutions, while copper bearing alloys such as cupro-nickel and

monel do not perform appreciably better than carbon steel.

Aluminum appears to be resistant to corrosion of glycol amine solutions in reboiler service, but a satisfactory design eliminating baffle cutting has not been evolved. In one installation operating with a glycol amine solution containing 20 percent water and at a reboiler temperature of 275° F., alumium reboiler tubes have proven to be very satisfactory over several years.

It is thought that in a properly operated glycol amine plant carbon steel tubes should give a sufficiently long service life to make the use of alloys unnecessary. There are several features which can be incorporated in the design of reboilers in order to alleviate corrosion. As pointed out above, the lowest possible temperatures should be maintained on both the solution and steam sides in order to minimize the metal skin temperature. To maintain the minimum steam temperature at all times, the steam rate control valve should be located in the steam line ahead of the reboiler instead of in the condensate line from the reboiler. Vibration of the tubes can be reduced by using a square pitch design permitting evolved gas to escape freely. This measure will also reduce accumulation of sediments. Finally, the level in the reboiler should be maintained high enough so that all the tubes are always covered with liquid.

Solution coolers and regenerator overhead condensers are not known to have been subject to corrosive attack from the solution or acid gas side, respectively, in glycol amine systems. In a few aqueous amine plants, solution cooler corrosion from the solution side has been reported. However, water side corrosion in carbon steel coolers and regenerator overhead condensers have been reported in several instances. With glycol amine plants, this problem can be overcome by the use of inhibited Admiralty tubes, as a number of field installations have shown that this material is not attacked by the cool glycol amine mixture.

A great deal has been learned on combating corrosion in amine systems during the past years. However, exact correlations have not been developed and corrosion problems still have to be solved for the most part on an individual plant basis. There are indications that the use of relatively inexpensive alloys is a more economical means for corrosion control than drastic plant design changes. The use of suitable inhibitors is a possible development for the future.

Steam Consumption. The relatively high utility cost in gas treating operations has made it desirable to devise schemes with lower process steam consumption than the conventional aqueous amine process. One of the earliest improvements is the so-called split flow cycle in which only a portion of the solution is completely reactivated in the stripping column and used for final cleanup of the gas. The remainder of the solution is partially reactivated in the top section of the still and used to absorb the bulk of the acid gas. The steam requirements in this cycle are appreciably lower than in the typical aqueous amine system.[3] However, a higher investment is required because of the increased complexity of the system.

The glycol amine process is another step in the direction of steam economy. The lower steam requirement of the glycol amine system can be explained as follows: The presence of glycol raises the boiling point of the solution, resulting in a higher temperature in the stripping column and reboiler. The higher temperature causes more complete dissociation of the amine-acid gas compounds so that a smaller quantity of stripping vapor is required to accomplish the desired stripping. As the greatest portion of the heat load is supplied to provide stripping vapor, the process steam consumption in a glycol amine plant is approximately one-half of that of an aqueous amine plant.

Selective absorption of H_2S in the presence of CO_2 can also result in considerable savings in steam consumption by decreasing the quantity of acid gas which must be stripped from the solution. The selective absorption process using MDEA described by Miller and Kohl,[9] has been demonstrated both on a pilot plant scale and commercially. The selective absorbant can be used either in aqueous solution or in combination with glycol, and gas of very high purity can be produced economically.

A very recent development in the direction of steam savings consists of washing the sour gas with water at high pressures as a pre-treatment before final purification with amine solution. A pilot plant test of this system was recently reported by the Shell Oil Company of Canada.[22] Extremely sour gas containing 32-35 percent H_2S and 12 percent CO_2 was subjected to water washing at a pressure of 500 pounds per square inch and a temperature of 100° F. Approximately 80-90 percent of the H_2S and 60 percent of the CO_2 were removed by the water. The water was stripped by reducing the pressure and flashing off the acid gas. Sufficient data are not available at this time to evaluate firmly the merits of this scheme. However, it appears that it is applicable only to gas streams of very high acid gas content because the solubility of H_2S and CO_2 in water is very dependent upon partial pressure.

ACKNOWLEDGMENT

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Part 2 will appear in a coming issue

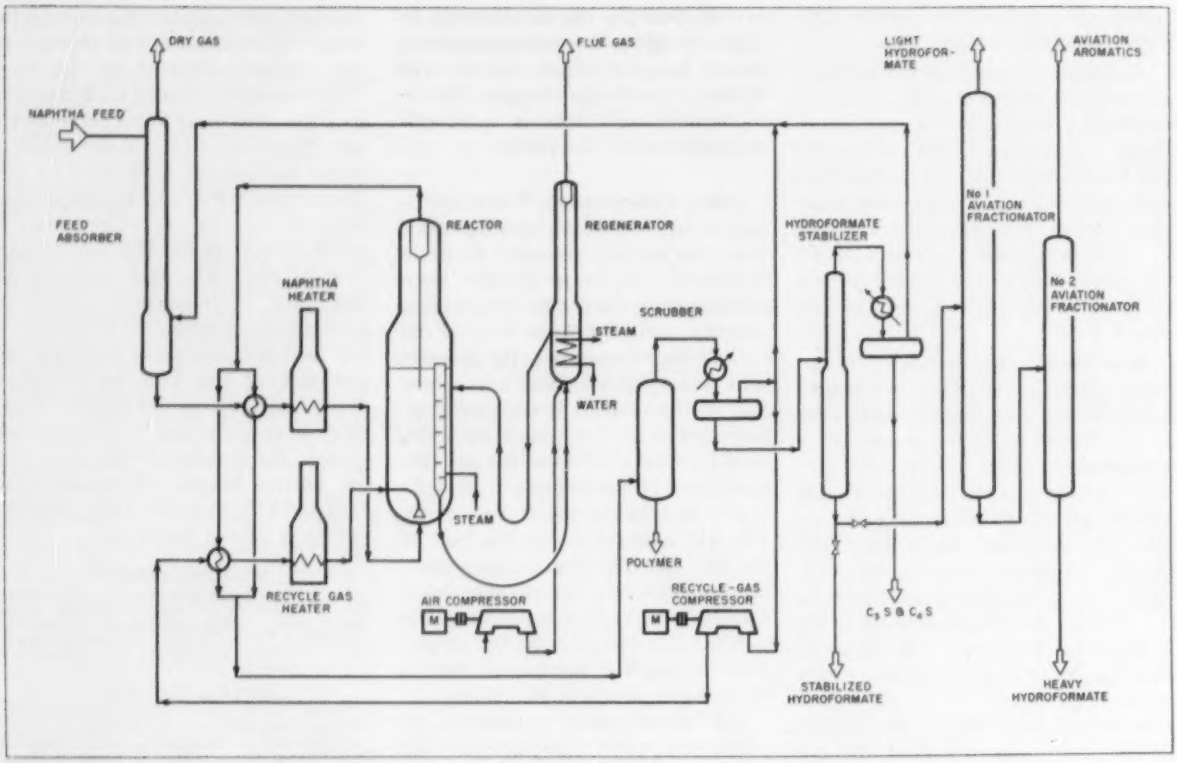

FIGURE 1—Simplified flow diagram of the Esso Baton Rouge Fluid Hydroformer.

How the . . .

Esso Fluid Hydroformer Performs

Here's the full story on the plant and the process.

Richard G. Winslow and Fred C. Hanker,
C F Braun & Company,
Alhambra, California

A NEW 28,000 barrel-per-stream-day fluid hydroformer is on stream at the Baton Rouge refinery of Esso Standard Oil Company. The unit is designed to produce either high-octane motor-fuel blending stock, or high-aromatics stock for aviation gasoline.

Fluid hydroforming is a fully continuous operation that uses established fluidized-solids techniques at relatively high pressure. Other characteristics of the process are operating flexibility, catalyst-stability, requiring no feed pretreatment for sulfur removal, capability of handling a wide range of feed stocks such as coker distillate, and unusually high octane-ceilings attainable.

The unit is designed to process 28,000 barrels of naphtha per stream day for the production of 85 clear Research octane-number motor-gasoline hydroformate. To produce 95 clear Research octane motor-gasoline, or aviation aromatics, the unit is designed to charge 22,000 barrels per day. Characteristics of the feed are summarized in Table 1, product yield and quality data, in Table 2.

The general process flow is shown in Figure 1. Naphtha feed enters the

TABLE 1—Feed Characteristics

Crude Type	La.-Miss.
Gravity, API	56.9
Sulfur, weight percent	0.004
ASTM Research Octane Number, Clear	51
ASTM Distillation:	
10 percent	228
50 percent	250
90 percent	290

TABLE 2—Yield and Quality Data

	85 Octane Motor Fuel Operation	95 Octane Motor Fuel or Aviation Aromatics Operation
CRUDE TYPE		
Reforming Yields		
Dry Gas, weight percent	5.0	10.0
Butane, volume percent	5.0	8.0
C_5 plus reformate, vol. percent	87.0	78.0
C_5 plus light reformate, volume percent	.....	25.4
Aviation aromatics, vol. percent	.....	44.5
Heavy Reformate, vol. percent	.....	8.0
Carbon, weight percent	0.7	1.0
C_5 Plus Reformate Properties		
Gravity, API	51.5	44.7
Sulfur, weight percent	<0.001	<0.001
ASTM Research Octane Number, Clear	85	95

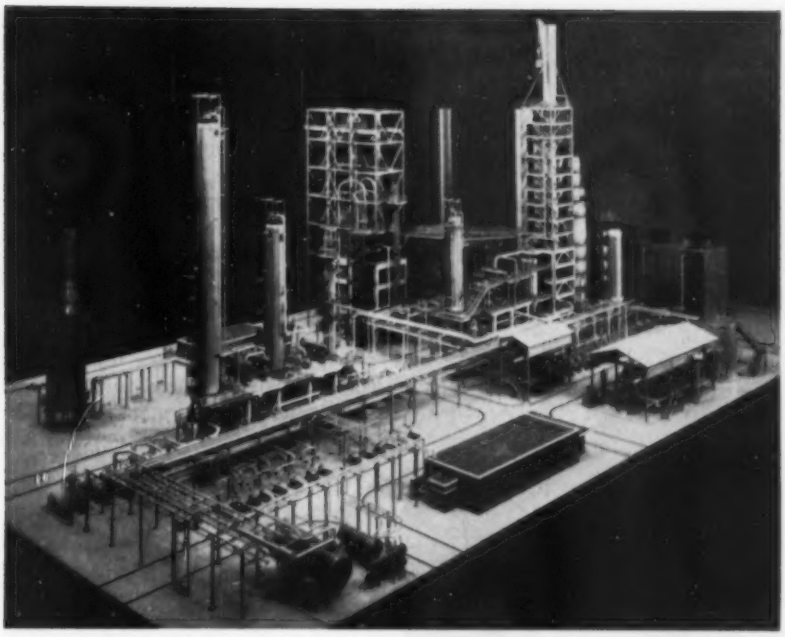

FIGURE 2—Scale model of the unit used as design aid and prestartup operator training tool.

feed-absorber as a lean oil and recovers hydrocarbons from the unit's combined tail-gas stream. The absorber bottoms, naphtha feed containing absorbed light ends and recycle gas, are preheated by exchange against hot reactor-product. Final heating is accomplished in two furnaces. Preheated feed and recycle gas enter the reactor near the bottom. Hot regenerated fluid catalyst enters the reactors at the side.

The product vapors which leave the fluidized catalyst bed are separated from entrained catalyst particles by cyclone recovery equipment located in the top of the reactor. The reactor effluent is cooled in heat exchange, and enters the scrubber tower at its base. Hydroformate of the desired end point, is taken overhead from the scrubber, and polymer is removed from the bottom. Part of the gas separated from the scrubber overhead-stream is recycled to the reactor to supply heat and to maintain hydrogen partial-pressure.

Spent catalyst is withdrawn from the reactor through a stripping section, where entrained hydrocarbons are purged from the catalyst. The stripped catalyst is carried to the regenerator by a portion of the regeneration air. The bulk of the regeneration air is injected directly into the regenerator. There, the catalyst is regenerated by continuous combustion of catalyst deposit. Surplus heat is removed through vertical water-tubes mounted inside the regenerator. Fluegas which leaves the fluidized bed is separated from entrained catalyst particles by cyclone recovery equipment located in the top of the regenerator. The fluegas then passes through a pressure control valve and silencer before release to the atmosphere.

The unstabilized hydroformate is charged to the stabilizer. On motor-fuel operations, the stabilizer bottoms are ready for blending with no further fractionation. When processing for aviation aromatics, the stabilizer bottoms are charged to a conventional two-tower fractionation system which produces light hydroformate, aviation aromatics, and heavy hydroformate.

Table 3 summarizes some design features of the unit. The main air-compressor is a motor-driven two-case, multi-stage centrifugal machine provided with water-cooled diaphragms and cooling between the cases. The cases are connected in tandem and are driven through a speed-increasing gear by a 4000-horsepower electric motor. This compressor operates at 7270 revolutions per minute

Meet the Authors

RICHARD G. WINSLOW spent two years in catalytic-cracking development work with the Engineering department of Phillips Petroleum Company, and three years in the process group at Phillips' Borger, Texas, refinery. After three years in Tulsa, as process engineer for Jones & Laughlin Construction Division, he joined the Project division of C F Braun & Company, where he is now senior chemical engineer. Winslow graduated from the University of Kansas in 1942, with a degree in mechanical engineering.

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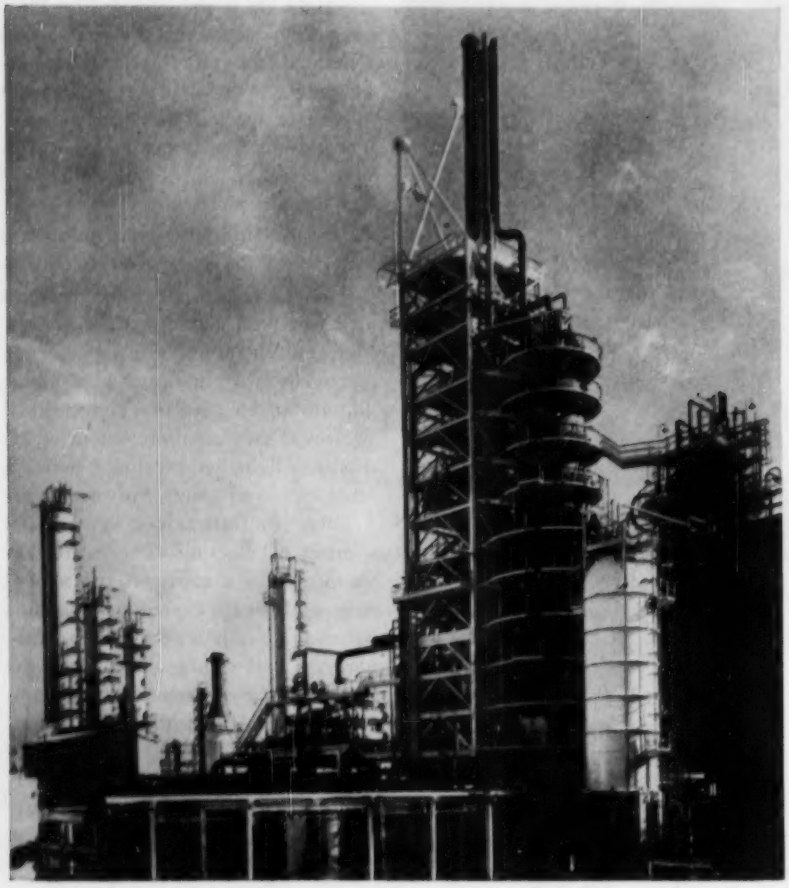

FIGURE 3—Reactor-regenerator structure with catalyst storage at right.

and delivers 9650 standard cubic feet per minute of air at 235 pounds per square inch gage.

The recycle gas-compressor is a motor-driven single-case multi-stage centrifugal machine. It is driven through a speed-increasing gear by a 4000-hp electric motor. In place of the usual suction control-valve, inlet guide vanes were provided on this machine to control flow.

The transfer-line exchangers handle reactor-product in tubes and either naphtha feed or recycle gas in shell. These exchangers, vertically mounted, are of the fixed tube-sheet type, with single-pass tubes 1½ inches in diameter and up to 40 feet long. Expansion joints are provided in shell. The joints are in shape of double convolution, and were fabricated from 1-inch thick plate, rolled and welded.

Experience had indicated that the fine catalyst carry-over from the reactor would "plate-out" in the tubes, seriously affecting the heat transfer rate. To prevent this "plate-out," provisions were made to recirculate a course sand flux to continuously scour the tube-walls and thus maintains heat transfer rates.

Vessels are carbon steel. The reactor, with metal thickness of two and one-half inches, was field-fabricated using automatic welding techniques. Following erection, the reactor was stress-relieved in place by heating with internal burners. All welds were gamma-ray inspected to the standards of the API-ASME Code. The reactor, designed for temperatures of 950 F, was internally insulated with castable insulation with welded reinforcement.

The regenerator was shop-fabricated and insulated in the field after erection. This vessel, designed for temperatures of 1175 F, was also insulated internally with castable insulation with welded reinforcement.

A scale model, Figure 2, was used in planning the layout of the unit. The objectives of this layout include ease of operation and maintenance with low investment. In the area to the right are the feed absorber, reactor, regenerator, scrubber tower, feed exchangers, preheat furnaces, and catalyst-storage hoppers.

The three-tower hydroformate fractionation-system is on the left. Pumps and exchangers are lined up down the center of the unit. In the foreground is the control house which provides supervisory office space, control-laboratory, and locker room and sanitary facilities for the operators. There are 4.1 acres within the battery-limit dimensions of 340 feet by 525 feet.

Plant design provides for maximum use of mobile handling-equipment for maintenance of pumps and drivers and shell and tube equipment. Clear areas throughout the unit permit free movement of the motorized equipment and give ready access to process equipment. A permanent railway spur for catalyst cars runs to one corner of the unit.

TABLE 3—Design Summary

Compressor, Brake Horsepower:	
Air	4,000
Recycle Gas	4,000
Total	8,000
Furnaces, total heat absorbed MM B.t.u./per hr.	200
Heat-transfer, surface, square feet	101,600
Reactor and Regenerator Steel, pounds	835,000
UTILITIES CONSUMPTION	
Hydroforming Section	
Power, Kilowatts	6,900
Cooling-Water, 87 F, GPM	7,400
Steam, net pounds per hour at 600 psig	18,000
UTILITIES PRODUCTION	
Hydroforming Section	
Steam, net pounds per hour at 110 psig	4,000

There are two main structures. One supports the regenerator and contains an elevator for access. The platforms around the reactor tie into this structure. Thus, the reactor and the regenerator are both readily accessible for operations or maintenance.

A second main structure supports the vertical transfer-line exchangers. A traveling crane at the top of the structure services these exchangers.

Each fractionating tower was designed with segmental platforms and a platform at the top of the tower. An overhead trolley rail and hoist provides for the removal of tray parts and general servicing.

The process was developed by Esso Research and Engineering Company, formerly Standard Oil Development Company, and was engineered and constructed by C. F. Braun & Co.

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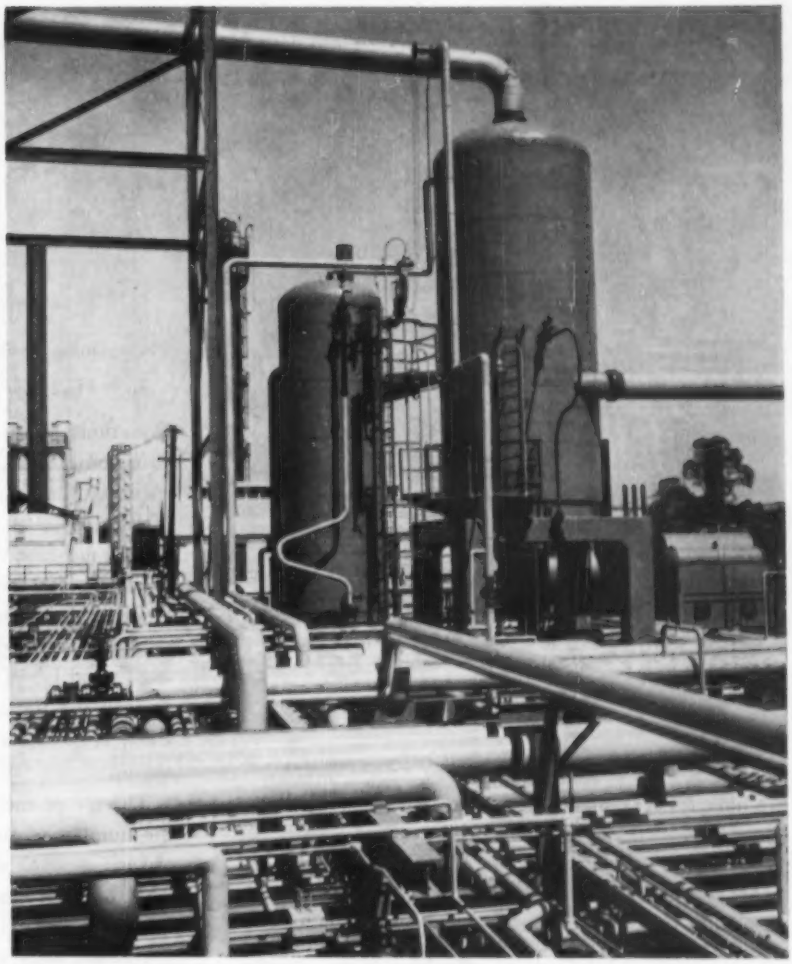


Crude distillation section — Complex piping means complex design.

Here's how to save time in computing stresses in a three-dimensional piping system:

New Method for Pipe Stresses

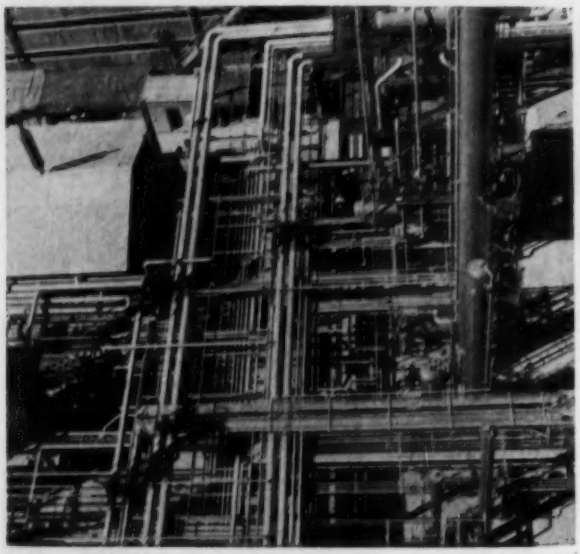
Part 1. How to Use the Tabular Method

Part 2. Systems with Different Moments of Inertia

Part 3. How to Handle Elbows and Bends

K. Hao Hsiao,
The Ralph M. Parsons Company,
Los Angeles

When the piping system contains branches with different moments of inertia, ratios of the cross-sectional moments of inertia are applied to the equations for piping with constant moment of inertia, i.e., Eqs. (5), (6), and (7), by multiplying l's and I_o's in Eqs. (10) by these ratios. For instance, if the piping system contains only branches ab and bc with moment of inertia I_1 and the remaining branches with I_2, then from Eqs. (10)



Catalytic polymerization unit—Good design for integrated piping.

we have for X-Y plane,

$$(I'_x)_{ab,\,bc} = \sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i y_i^2 + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} \left(\frac{I_2}{I_1} l\right)_i y_i^2 - \bar{y}^2 \left[\sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} \left(\frac{I_2}{I_1} l\right)_i\right]$$

$$(I'_x)_{cd,\,de\,\ldots} = \sum_{i=cd,\,de\,\ldots} l_i y_i^2 + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} l_i y_i^2 - \bar{y}^2 \left[\sum_{i=cd,\,de\,\ldots} l_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} l_i\right]$$

and, for X-Z plane,

$$(I''_x)_{ab,\,bc} = \sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i z_i^2 + 0.3 \sum_{i=\text{Branches} \parallel \text{Y-axis}} \left(\frac{I_2}{I_1} l\right)_i z_i^2 - \bar{z}^2 \left[\sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Y-axis}} \left(\frac{I_2}{I_1} l\right)_i\right]$$

$$(I''_x)_{cd,\,de\,\ldots} = \sum_{i=cd,\,de\,\ldots} l_i z_i^2 + 0.3 \sum_{i=\text{Branches} \parallel \text{Y-axis}} l_i z_i^2 - \bar{z}^2 \left[\sum_{i=cd,\,de\,\ldots} l_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Y-axis}} l_i\right]$$

The centroidal moments of inertia I_{ox} are

$$(I_{ox})_{ab,\,bc} = \frac{I_2}{12 I_1} \sum_{i=ab,\,bc} (l_y^2 + l_z^2)_i$$

$$(I_{ox})_{cd,\,de\,\ldots} = \frac{1}{12} \sum_{i=cd,\,de\,\ldots} (l_y^2 + l_z^2)_i$$

Combining the above terms, we have, for the piping system,

$$I_x = (I'_x)_{ab,\,bc} + (I'_x)_{cd,\,de\,\ldots} + (I''_x)_{ab,\,bc} + (I''_x)_{cd,\,de\,\ldots} + (I_{ox})_{ab,\,bc} + (I_{ox})_{cd,\,de\,\ldots} \qquad (15)$$

From Eqs. (10), the products of inertia in X-Y plane are

$$(I_{xy})_{ab,\,bc} = \sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i y_i^2 + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} \left(\frac{I_2}{I_1} l\right)_i x_i y_i - \bar{x}\bar{y} \left[\sum_{i=ab,\,bc} \left(\frac{I_2}{I_1} l\right)_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} \left(\frac{I_2}{I_1} l\right)_i\right]$$

and

$$(I_{xy})_{cd,\,de\,\ldots} = \sum_{i=cd,\,de\,\ldots} l_i x_i y_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} l_i x_i y_i - \bar{x}\bar{y} \left[\sum_{i=cd,\,de\,\ldots} l_i + 0.3 \sum_{i=\text{Branches} \parallel \text{Z-axis}} l_i\right]$$

Combining the above terms, we have, for the piping system,

$$I_{xy} = (I_{xy})_{ab,\,bc} + (I_{xy})_{cd,\,de\,\ldots} \qquad (16)$$

Equations for I_y and I_z are similar to Eq. (15), and equations for I_{xz} and I_{yz} are similar to Eq. (16). Substituting these line inertia values on the left-hand side of Eqs. (5), (6) and (7), and substituting I_2 for I on the right-hand side of the same equations, we obtain three equations for solution of X, Y and Z forces, which are identical in form to the equations for a piping system with constant moment of inertia. Therefore, by multiplying l's and I_o's of branches ab and bc with the ratio I_2/I_1, we can use the same tables, i.e., Tables 1, 2 and 3 (see Part 1, October, 1955, REFINER) to obtain bending moments and torques.

The use of the above I_2/I_1 ratio is most efficient when the number of piping branches with I_2 far exceeds that of I_1. In general, when the piping system contains branches with different cross-sectional moments of inertia I_1, I_2, I_3, . . . I_n, of which the number of sections with I_n is predominant, then we apply ratios I_n/I_1, I_n/I_2, . . . I_n/I_{n-1} to the l's and I_o's of branches with cross-sectional moments of inertia other than I_n, and substitute I_n for I in Table 1.

Example 2

The tabular solution for a piping system with different cross-sectional moments of inertia can be illustrated by using the system in Example 1 and changing branch ab from 10 inch diameter to 8 inch diameter, schedule 40 ($I = 72.5$ in^4).

Since, in this case, the number of 10-inch pipe branches is predominant ($I = 160.8$ in^4), we apply the ratio $\frac{160.8}{72.5} = 2.22$ to the length and centroidal moment of inertia of branch ab as below.

$$l_{ab} = 2.22 \times 15 = 33.3 \text{ ft.}$$
$$(I_o)_{ab} = 2.22 \times \frac{15^3}{12} = 624 \text{ ft.}^3$$

Replacing values for branch ab in Table 1 of Example 1 with the above values and using $I = 160.8$ in^4, we obtain the tabular solution for this piping system with different moments of inertia.

Part 3 will appear in a coming issue.

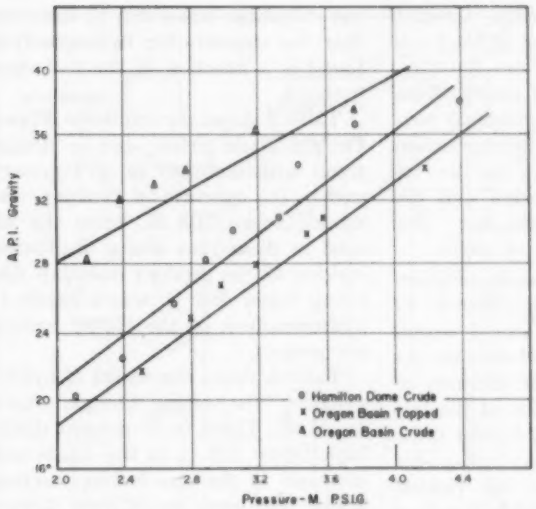


FIGURE 1—The increase in API gravity of the crudes as a function of the pressure of the hydrogenation reaction.

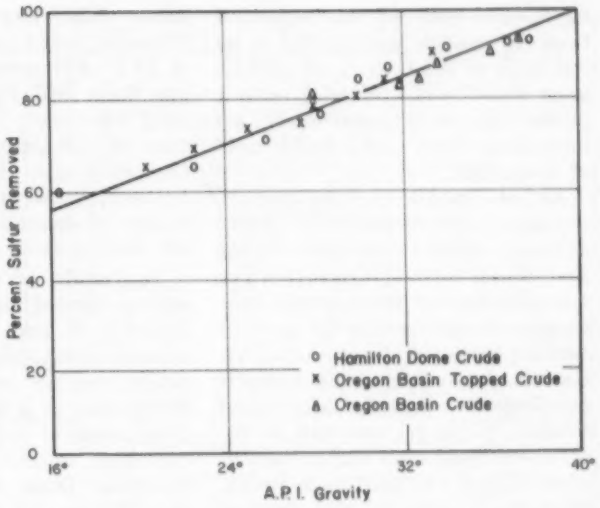


FIGURE 2—Sulfur removal as a function of increased API gravity of the crude.

Hydrogenating Wyoming Black Oils

Pilot plant tests indicate that these crudes can be improved substantially by high-pressure hydrogenation.

Ralph D. Law
Natural Resources Research Institute, Laramie, Wyo.

WYOMING ROCKY MOUNTAIN crude oils present the following problems to refiners:

- Large amounts of carbon are laid down on cracking catalysts
- Excessive amounts of gaseous products are formed
- A fraction is encountered which does not crack and which actually distills from a coking process without coking.

A program was instituted by the Natural Resources Research Institute to determine the effect of high-pressure catalytic hydrogenation on these oils.

The investigation disclosed evidence that the black oils were composed largely of cyclic and polycyclic structures with the polycyclic compounds predominating in the higher boiling fractions.

Structures containing 2, 3, 4 and 5 ring nuclei were isolated from fractions boiling above the naphtha range. These polycyclic structures showed considerable aromaticity, especially those with boiling points above 300 C.

Several of the lower boiling compounds such as anathracene, phenanthrene, and naphthacene were isolated and identified in the non-cracking portion of the oil.

A few additional compounds (pentacene, pyrene, benzanthracene) were tentatively identified without proof of structure. These compounds were all 3, 4 and 5-ring structures and completely aromatic; indicating that the non-cracking fraction was composed of a mixture of constituents entirely aromatic in constitution.

Meet the Author

RALPH D. LAW, in addition to teaching refinery processes at the University of Wyoming, also serves as petroleum research chemist in the university's Natural Resources Research Institute, where his job is to carry out research on black crude oils and creosote oil from low-temperature coal carbonization. His experience includes some ten years as a teacher at North Dakota State Teachers College and the University of Colorado, where he received his Ph.D. in chemistry.

Apparatus and Method—The pressure apparatus used for hydrogenation is a rocking autoclave provided with a cylindrical heater and a pressure gage. The reactor body is of type 410 stainless steel bar stock having a capacity of 2700 ml.

The charge to the reactor was 500 ml of commercial grade nickel catalyst and 500 ml of the crude oil or residue. The reactor was then pressurized with hydrogen to the desired total pressure at room temperature, and heated to 390 C. This temperature was held for 30 minutes at which time the heat was turned off and the apparatus allowed to cool over-

night. The cold oil was separated from the catalyst and distilled to an end point of 205 C, S. T. P. (195 C, at an elevation of 7165 feet) using a packed column of approximately ten theoretical plates and a reflux ratio of about 10:1.

API and specific gravities were determined with hydrometers. Sulfur determinations were made by the Shell-Brown method. Quantitative determinations of the aromatic type compounds contained in the material distilling below 205 C were made on a small glass adsorption column as described by Rossini, Mair, and Schafer.[1] Silica gel was used as the adsorbent in all cases and 95 percent ethyl alcohol was used as a pusher. Refractive indices of the desorbed fractions were measured with a precision refractometer at 20 C.

Results and Discussion—11.1° API gravity black oil from the Hamilton Dome field, Hot Springs County, Wyoming, and a mixture of black oils of 23.5° API gravity from the Oregon Basin field, Park County, Wyoming were used. The principal purposes of this series of hydrogenation runs were to determine; (a) the relationship between pressure and the degree of hydrogenolysis and; (b) the relative elimination of sulfur.

The results of the hydrogenation studies carried out are shown in Tables 1, 2, and 3. Table 1 shows a definite relationship between the reaction pressure and the increase in API gravity as a function of the hydrogenolysis of large molecular units contained in the heavy oil. This Hamilton Dome crude oil yielded only 34.5 percent distillable fractions when distilled to a temperature of 700 F., showing presence of a high percentage of asphaltic materials. The progressive increases in the quantity distillable below 205 C. indicates that the quantitative hydrogenolysis found is a function of the hydrogen pressure.

Table 2 shows the results on topped Oregon Basin crude and a similar trend with increases in API gravity and in the quantity of products distillable below 205 C. Since the oil used in these runs was a distillation residue all the product materials distilling below 205 C. was a result of hydrogenolysis of the higher boiling compounds.

Table 3 shows the results of hydrogenating the virgin Oregon Basin crude oil. There is 15 percent distillable below 205 C. in this crude and increases in the low boiling fraction above this level result from hydrogenolysis of higher boiling compounds. Figure 1 shows graphically the relationship between reaction pressure and the degree of hydrogenolysis as indicated by increase in API gravity for all of the three series of reactions.

During the preliminary examinations of the distilled fractions it was noted that as the degree of hydrogenolysis was increased, the quantity of olefins and aromatics increased. The aromatic content of the low boiling fractions obtained above 4000 pounds per square inch gage was 47.1 percent and 46.6 percent in the hydrogenated Hamilton Dome and topped Oregon Basin series respectively.

Sachanen[2] proposes the mechanism by which low boiling aromatic and olefinic compounds are produced from long chain paraffins, cyclic alkanes and aromatic rings during the hydrogenation reaction.

The elimination of sulfur as hydrogen sulfide is related to the extent of hydrogenolysis and, thus, to the reaction pressure. The percent of sulfur removal as a function of the degree of hydrogenolysis is shown in Figure 2. Here the API gravity is a measure of the degree of hydrogenolysis. The results as shown indicate that sulfur removal from the polycyclic structures present in these oils is dependent upon the hydrogenolysis reaction. This indicates steric hindrance to the reaction between hydrogen and sulfur until the interfering structures are removed.

TABLE 1

Hamilton Dome Crude Oil

A.P.I. Gravity 11.1°, Sulfur Content 4.57%—Distillable Below 205° C—5.9%

No. Run	Maximum Reaction Pressure, psi	API Gravity Hydrogenated Oil	Percent Sulfur Hydrogenated Oil	Percent Sulfur Eliminated	Percent Distillable Below 205 C.
1	2100	16.3°	1.89	58.4	9.7
2	2500	22.5°	1.63	64.3	13.9
3	2700	25.9°	1.34	70.7	17.0
4	2900	28.4°	1.07	76.8	21.6
5	3050	30.1°	0.73	84.0	30.1
6	3300	31.3°	0.47	87.7	34.1
7	3450	34.2°	0.38	91.7	40.6
8	3800	37.1°	0.32	93.0	55.1
9	4450	38.0°	0.29	93.7	56.9

Variation of Aromatic Content = 19.2—47.1 percent.
Variation of Olefinic Content = 13.2—50.4 percent.

TABLE 2

Topped Oregon Basin Crude

A.P.I. Gravity 17.8°, Sulfur Content 2.84%, Initial Boiling Point 205° C

No. Run	Maximum Reaction Pressure, psi	API Gravity Hydrogenated Oil	Percent Sulfur Hydrogenated Oil	Percent Sulfur Eliminated	Percent Distillable Below 205 C.
1	2100	20.6°	1.01	64.7	14.1
2	2500	22.5°	0.89	68.8	16.6
3	2800	25.3°	0.74	74.0	18.0
4	2950	27.5°	0.64	75.4	21.9
5	3200	28.2°	0.61	78.5	22.3
6	3500	30.2°	0.52	81.7	25.2
7	3600	31.4°	0.42	85.2	25.9
8	4200	33.8°	0.27	90.5	36.4

Variation of Aromatic Content = 18.7—46.6 percent.
Variation of Olefinic Content = 8.9—53.4 percent.

TABLE 3

Oregon Basin Crude Oil

A.P.I. Gravity 23.5°, Sulfur Content 2.37%—Distillable Below 205° C—15.0%

No. Run	Maximum Reaction Pressure, psi	API Gravity Hydrogenated Oil	Percent Sulfur Hydrogenated Oil	Percent Sulfur Eliminated	Percent Distillable Below 205 C.
1	2200	28.2°	0.67	81.4	25.0
2	2400	32.2°	0.41	82.5	31.3
3	2600	33.0°	0.27	84.5	34.1
4	2800	33.8°	0.26	88.9	35.4
5	3200	36.4°	0.23	90.2	42.3
6	3800	37.5°	0.15	93.6	48.9

Variation of Aromatic Content = 9.8—39.4 percent.
Variation of Olefinic Content = 7.3—33.1 percent.

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2. Sachanen, A. N. Conversion of Petroleum, Chapter 5. New York: Reinhold Publishing Corporation, 1948.

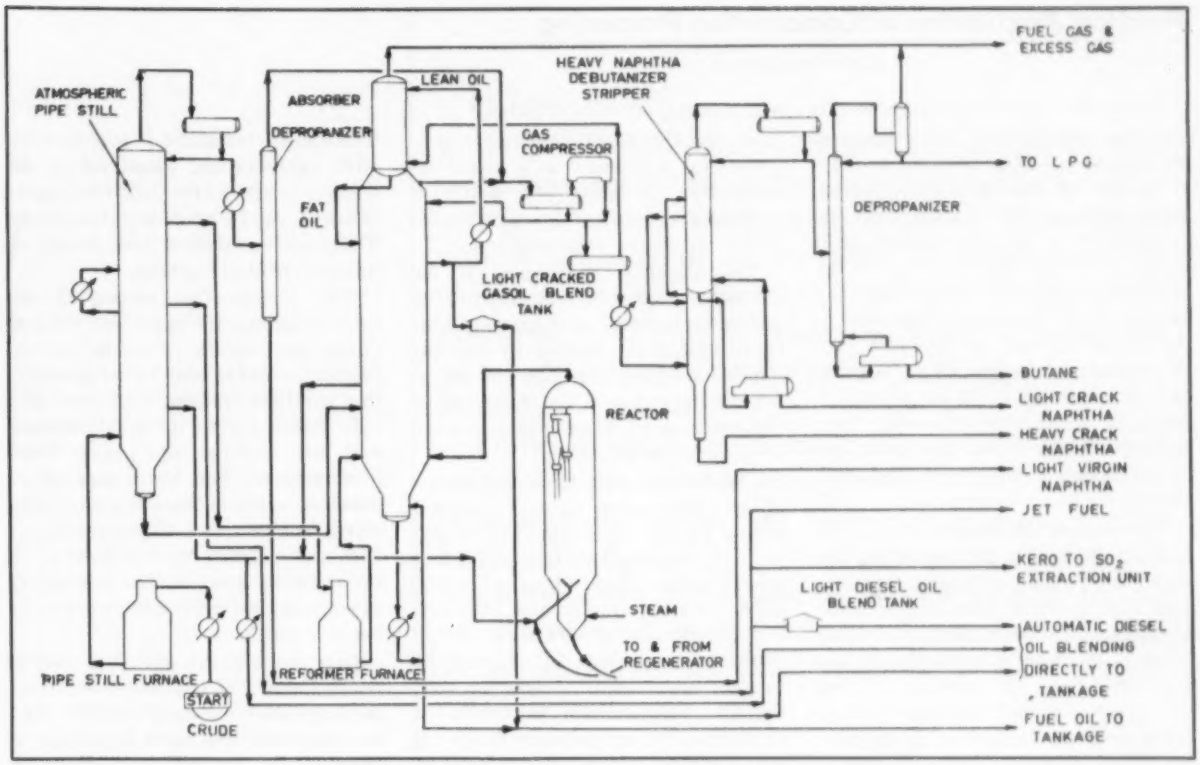


FIGURE 1—Schematic flow plan of a fluid combination unit.

A practical application of . . .

Combination Processing

- **High investment savings**
- **Minimum operating costs**

J. A. Beukers and H. P. Kelder,
Esso Standard Refinery,
Antwerp

A TYPICAL example of the fluid combination unit as designed by Standard Oil Development Company is located at Antwerp, Belgium. It is the heart of a refinery owned and operated by Esso Standard Refinery, S. A. The refinery consists of the fluid combination unit, a treating area comprising an SO_2 extraction unit for kerosine plus gasoline and kerosine sweetening facilities, a small boiler plant, gasoline blending facilities and the usual oil movement and storage facilities required to receive crude oil by tanker and to ship products by tanker, barge railcar, or truck. Electricity is bought from a nearby powerhouse.

The refinery and thus the combination unit was designed to process 25,000 bpcd Middle East crude oil for the production of fuel products, viz: two grades of gasoline, kerosine, jet fuel, three grades of diesel oils, two grades of residual fuel oil and butane LPG. In actual practice, several other than normal grades of gasoline, diesel and fuel oils have been manufactured and shipped.

A schematic flow diagram of the combination unit is indicated on Figure 1. The crude oil is distilled in a conventional atmospheric pipestill into a light virgin naphtha overhead, three side streams and a reduced crude bottoms stream. Three alternate operations are possible with the No. 2 sidestream producing either kerosine, a light diesel oil blending component or jet fuel. The light naphtha is pumped to a depropan-

izer for stabilization and thence to the sweetening area. Here the product is sweetened directly without passing surge capacity. Heavy virgin naphtha is produced as the first sidestream; it is sent directly and thus hot to the reformer furnace. When producing the diesel oil blending component as second sidestream, an excess is produced over that required for reforming. A relatively small surge tank is available to receive reformer feed during this diesel oil operation and to make-up for shoratge of feed stock during the other operations.

The second sidestream is sent to a small surge tank when producing the diesel component, to kerosine extraction feed tankage when on kerosine operation and to jet fuel sweetening when in this type of operation. In the last operation, the product is sent directly to finished product tankage from the combination unit after passing the sweetening step. The third sidestream is also a gas oil suitable for blending into diesel oils. It is mainly used for this purpose although part of the stream may be included in the feed to the catalytic reactor. The stream is sent directly to finished diesel oil tankage after line blending in the proper proportions with the light virgin diesel oil component and light cracked diesel oil. An automotive, an industrial and a marine grade of diesel oil are produced in this manner. Small surge tanks are available for the light virgin and the light cracked diesel components. The tank for the first mentioned component is somewhat larger in order to compensate for the blocked operation when producing the various qualities of second sidestream and to insure a continuous supply of the product for the diesel oil blending operations.

The pipestill bottoms are transferred by way of an accumulator to the fractionator. Heat exchange is applied where possible. The crude is divided into three streams and picks up heat from the pipestill pumparound system, from the hot lean oil and from the fractionator bottoms. In the last case the stream has first supplied the necessary preheat to the feed entering the light ends facilities as will be described later. The heat from the third sidestream is used partly for a reboiler in a glycol regeneration operation and partly to preheat the light virgin naphtha before it enters the depropanizer.

The naphtha reformer is fed through a high pressure pump. Coil outlet temperature and pressure may be regulated as dictated by gasoline quality requirements. The hot vapors are discharged into the flash zone of the combination fractionator through a hand controlled valve.

The fluid catalytic cracking section of the combination unit consists of a Model IV unit as designed by Standard Oil Development Company. It is a heat balance unit. Hot feed is supplied from the fractionator, if necessary supplemented with some gas oil from the crude pipestill. Except by varying the catalyst circulation rate, the heat balance may be controlled by varying the temperature of the cat feed produced at the fractionator by passing it through a cooler. The flue gases from the regenerator pass through a waste heat boiler to recover some of the heat lost to the air.

The combination fractionator-absorber tower combines into one tower the following functions:

1. Catalytic fractionator.
2. Reformer primary fractionator
3. Vacuum pipestill.
4. By-products and off-specification product rerun tower.
5. Light ends absorber and fat oil stripper.

The products from the fluid catalytic cracking reactor and the reformer products are the heating and lifting media for the reduction of the atmospheric reduced crude to the final crude residuum. It is withdrawn from the bottom of the tower after steam stripping and thence cooled by heat exchange, firstly by the light ends feed, secondly by cold crude and finally by water.

After heat exchange with light ends feed, a portion of the bottoms is returned to the bottom of the tower as quench for temperature control. The cooled residuum is line blended with light cracked diesel oil to the desired grades of fuel oil, two grades of which can be made simultaneously. These are transferred immediately to finished product tankage.

The fractionating section of the tower separates the vaporized reduced crude, the reactor products, the reformer products and rerun products into catalytic cracking feed stock and light cracked diesel oil as side streams and into naphtha and gas as overhead stream. The heavy gas oil or catalytic cracking feed is collected in a pan located inside the tower. From here the product is fed directly to the catalytic reactor. The pan serves as surge capacity for catalytic cracking feed stock.

Part of the heavy gas oil is used as reflux below the pan for tower temperature and cat feed quality control. As first sidestream a light cracked diesel oil or gas oil is produced. A large stream is withdrawn from the tower. A relatively small portion, equal to the net production of this product, is sent to a surge tank after steam stripping. It is mainly used for the continuous residual fuel oil blending while a portion is also used as blending stock for two grades of diesel oil.

This portion is caustic and water washed prior to the blending. The main portion of the first sidestream is cooled by part of the crude oil and pumped to the top of the absorber as lean oil after passing a water cooler. The fat oil from the absorber is gravitated back to the tower three trays above the lean oil draw-off. The absorber gases are stripped out in the tower. The first side stream is thus effectively used as:

1. Preheat medium for the crude (similar to the pumparound in the crude tower).
2. Lean oil for the absorber.

The overhead vapors from the fractionator are partially condensed at the fractionator tower pressure. The gases are then compressed and recontacted with the naphtha produced as overhead at the fractionator. This mixture is again condensed at the higher pressure. The uncondens-

able gases are transferred to the absorber for further recovery of valuable fractions. The absorber recovery may be controlled within certain limits by the amount of lean oil used for the absorption. The absorber outlet gas is transferred to the refinery fuel gas system. The naphtha product from the second distillate drum is pumped after heat exchange with the bottoms of the fractionator tower to a stripping section of a debutanizer tower.

Stripped heavy cracked naphtha is withdrawn from the bottom and sent to sweetening via a small surge drum. The overhead vapors from the stripper are partly condensed and fed into the debutanizer section of the tower. The stabilized light cracked naphtha is sent as bottom product via a surge drum to sweetening. A side stream from the debutanizer section is used as reflux for the top of the stripper section.

The overhead vapors from the debutanizer are totally condensed and fed into a depropanizer tower. The bottoms containing pentanes and butanes are caustic washed and used for gasoline blending. The overhead product is again totally condensed and transferred to an LPG tower in which butane LPG is produced as bottoms product. The overhead is partially condensed and transferred to a vaporizer drum. The product may be used as gaseous plant fuel in case of gas shortage. The gas from the LPG tower is sent to the fuel gas system. Fuel gas is used at the unit furnaces and the boilerhouse. Excess gas is freed from water in a glycol scrubber and thence transferred to a nearby powerhouse.

Also available in the area controlled by the combination unit personnel is a deodorizer. Its feed stock consists of spent caustic streams and H_2S bearing water streams. These are countercurrently contacted with hot flue gases from the crude furnace for H_2S and caustic neutralization. The outlet gas from the deodorizer is returned to the crude furnace to burn the H_2S.

The entire operation is controlled from a central control room equipped with a graphic panel on which the flow is indicated through the successive sections of the combination unit. In combination processing, the availability of a graphic panel is an almost indispensable tool to control properly the highly integrated sequence of operations.

Table 1 gives typical yields from Middle East crude as produced at the fluid combination unit without the production of lamp kerosine.

At Antwerp refinery, it has been possible through minor equipment changes to increase the streamday capacity of the unit to about 20 percent above the design crude running capacity. A start-up of the unit does not present unusual problems. The entire unit is usually on stream within 48 hours after lighting the fires in the crude furnace. Slop production with combination type units may become very low and it seems possible to reach a level of 0.2 volume percent on crude for the entire refinery which includes oil movement and storage operations.

The refinery organization is provided with a minimum of maintenance personnel. The routine inspection period takes place only once per 12 to 18 months. During such periods, almost the entire refinery is out of operation and it is necessary to bring in outside personnel in order to achieve a minimum turnaround period. Provisions are also available to clean, inspect and repair certain pieces of equipment and parts of the unit at any convenient time. Such practice reduces the total shutdown time of the entire unit.

This paper was presented before the Fourth World Petroleum Congress and is published through the courtesy of Carlo Colombo, Campo Marzio 74, Rome. The complete text of this paper will be published in the proceedings and may be obtained directly from Mr. Colombo. # #

Conclusions

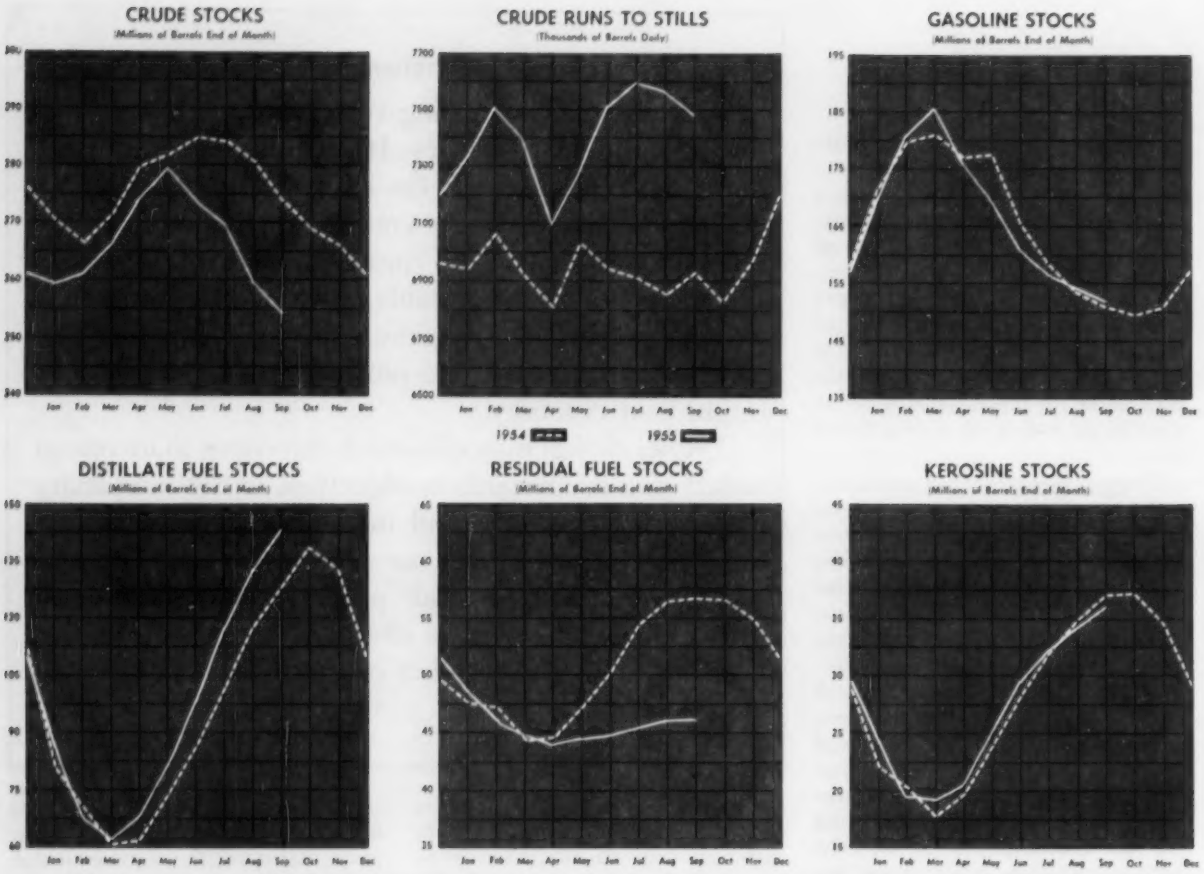
Combination processing represents a valuable tool in the petroleum industry. It may be applied in various processing fields; in the example described in this article an entire refinery consists almost of one single unit. Application of the combination processing technique results in considerable investment savings while operating costs may be minimized due to a reduction in manpower and to the possibility of applying optimum heat economy.

Proper design may eliminate objections to increased safety and fire hazards or objections to the complexity of routine inspection and maintenance work. Proper instrumentation, liberal use of automatic control and the application of graphic panels will greatly reduce or eliminate the possible effects of operational upsets in one section on the other processing steps of a combination unit.

TABLE 1—Typical Yields in Vol. % on a Middle East Crude

Excess Gas*	3.2%	
Gasoline and L.P.G.	35.9%	77.5 Res. Oct. clear 89.2 Res. Oct. 3 ml TEL/U.S. gal.
Middle Distillates	29.7%	
Heavy Fuel Oil	26.8%	165 SSF at 122° F.
Refinery Fuel (Cat. Cracker Coke incl.)*	4.9%	
	100.5%	

* Fuel Oil equivalent.


CRUDE STOCKS
(Millions of Barrels End of Month)
CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)
GASOLINE STOCKS
(Millions of Barrels End of Month)
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)
RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)
KEROSINE STOCKS
(Millions of Barrels End of Month)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1954
1955

Taking Stock

Cecil W. Smith,
Economics Editor

- Distillate stocks reach new high
- Refinery runs cut substantially
- Gasoline stocks on par with 1954

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1953:													
August	6,583	7,163	285,352	3,592	146,050	321	35,711	1,437	119,542	1,222	50,007	672	946
September	6,557	7,023	289,614	3,521	144,184	330	37,280	1,448	126,709	1,203	50,516	692	1,013
October	6,262	6,872	287,541	3,437	144,495	355	38,161	1,462	135,409	1,184	50,820	639	990
November	6,277	6,987	283,021	3,528	150,747	354	36,271	1,463	133,381	1,223	51,267	648	1,120
December	6,238	6,964	276,676	3,628	159,949	378	29,070	1,441	111,944	1,247	49,370	598	1,121
1954:													
January	6,240	6,947	270,811	3,431	171,704	390	22,013	1,467	81,044	1,271	47,474	617	1,143
February	6,379	7,068	266,918	3,476	179,950	412	20,183	1,545	70,390	1,241	47,119	621	1,144
March	6,507	6,923	271,867	3,375	181,297	353	17,533	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	755	1,155
September	6,668	7,484	254,775	3,683	151,266	294	36,413	1,611	143,722	1,088	46,754	846	1,162
Week Ended:													
10–14–55	6,714	7,357	255,134	3,652	150,480	291	37,228	1,557	148,849	1,091	47,288	694	1,003
10–15–54	6,196	6,765	271,061	3,299	150,676	325	38,796	1,452	133,253	1,076	56,184	524	866

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

● This photograph shows the welding of Revere 70-30 Cupro-Nickel to make a digester to handle both organic and inorganic acids. The metal was chosen because of its superior corrosion-resistance. It is also widely used for condenser tubes and plates, heat exchangers, evaporators, stills and similar equipment where its enduring qualities are required to meet corrosive fluids such as salt water and many chemicals.

The digester shown was made by the Nooter Corporation, 1430 S. Second St., St. Louis 4, Mo., which is an important supplier to the chemical, refinery, utility and similar industries. Weight of the vessel, 9,000 pounds; length, nine feet, inside diameter, 66 inches. Revere collaborates closely with Nooter from time to time on welding matters. If you have a welding problem on non-ferrous metals, see the nearest Revere Sales Office.

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AT THE DEPARTMENTS IN THIS ISSUE

How To Do It — PAGE 228

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Who's Building — PAGE 238

KEEP GOING for a rapid-fire summary of construction activity in our mushrooming industry along with a quarterly "boxscore" of building projects.

What's Happening — PAGE 258

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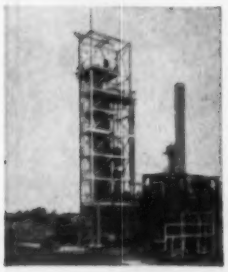

On July 30, 1955, Lummus turned over to Canadian Petrofina, Ltd., the 16,000 BSD Houdriflow Catalytic Cracking Unit and the 3,000 BSD Hydrodesulfurization Unit built at their new Point Aux Trembles Refinery near Montreal.

Construction on these two units began late in April, 1954, with the client requesting that the plant be completed by September 1, 1955. Substantially ahead of schedule by March, 1955, Lummus and the client agreed to use an absolute minimum of overtime labor for the remainder of the project to allow simultaneous completion of other refinery facilities. Even so, the two units were completed ahead of schedule, at a cost below the original guaranteed maximum.

Lummus constructed the Catalytic Cracking Unit complete with a charge heater system, Fractionation Unit, and Vapor Recovery Unit. The Hydrodesulfurization Unit (built under Shell license) is the second of these units in the world (Lummus having completed the first at Stanlow, England early in 1955). An outstanding feature of these units is the electronic instrumentation for temperatures, pressures and flow rates, complete with digital indication and adapted to automatic print-out logging and graphic panels. This is the first electronically instrumented Catalytic Cracking Unit in this hemisphere.

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16,000 BSD Houdriflow Catalytic Cracking Unit

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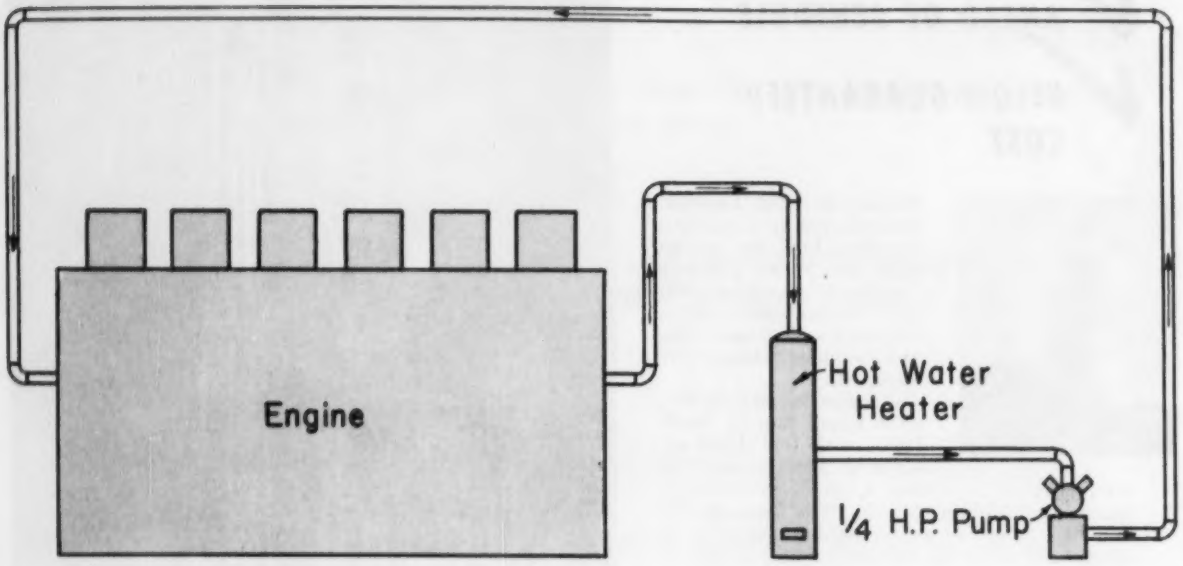
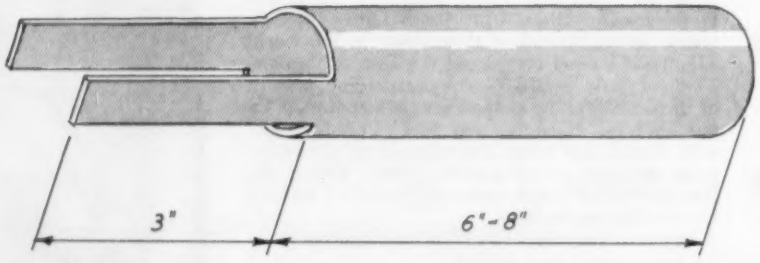


Water Heater Keeps Engines Warm for Winter Starts

The problem of starting dead cold engines in plants located where climates are severe, can be a sticky one. Often times there is sudden need to bring the stand-by engine to full load in the shortest possible time and when the engine is dead cold, this can produce very undesirable affects.

Here is a simple way to side-step the problems of long warm-up time unloaded, condensation in cylinders and bases, and excessive maintenance and down time. Just cut a small water heater and circulating pump into your jacket cooling system in the manner shown.

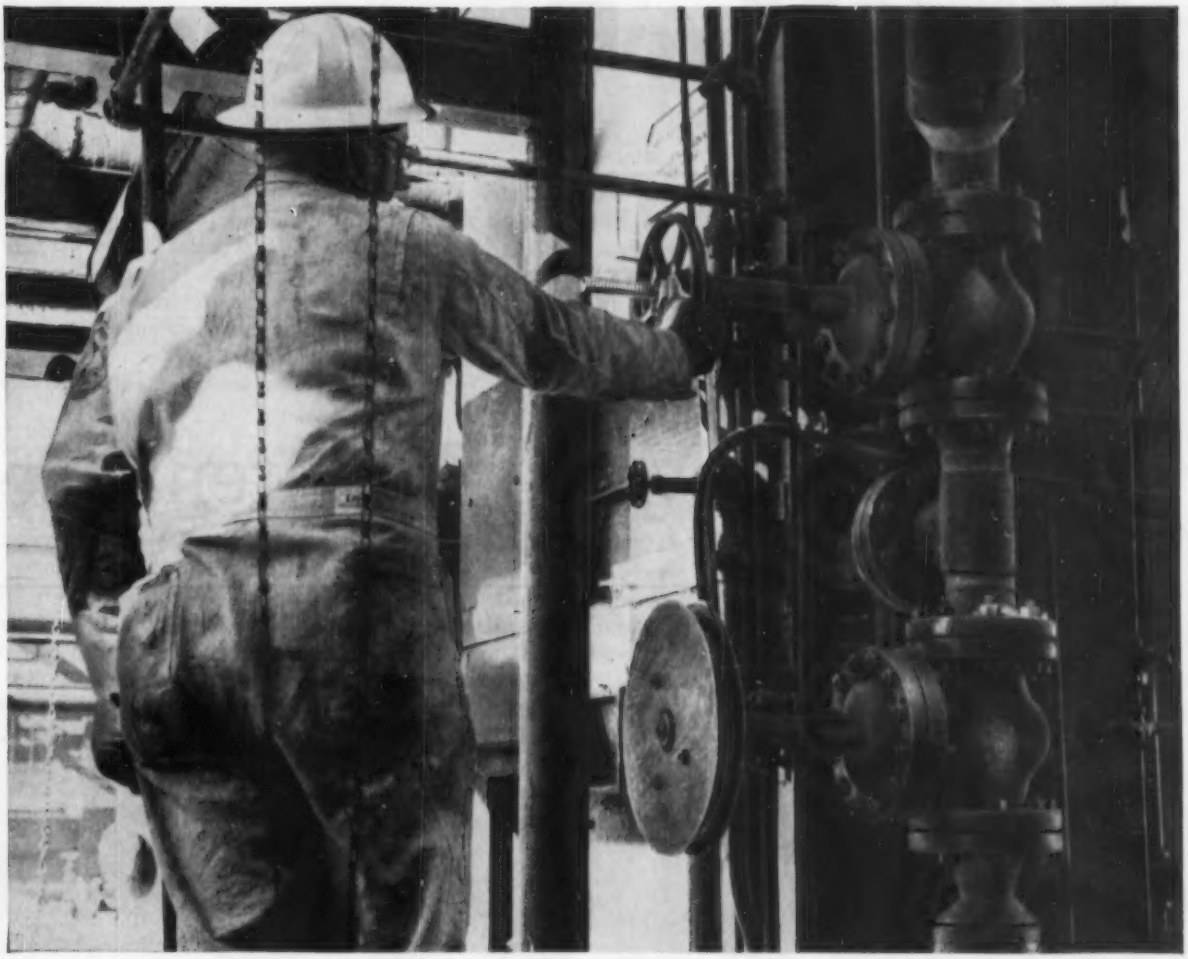
In this way, the engine can be maintained in a ready for operation condition and the condensation and other undersirable features will be minimized. This arrangement can be made for a very nominal cost and will probably save many times more than its initial cost in better engine performance and less down-time.



Tool Lines Up Compressor Valve Plates

To help line up compressor valve plates, make two tools like the one shown from 1-inch pipe. Cut the section of pipe the proper length to provide six to eight inches for a handle plus the length required to pass from the outside of the stop plate to the inside of smallest plate. Saw out two sections to make fingers to reach through the valve plates. Flatten these two strips, square the edges and round the points. Different size pipe may be used to fit the size of plate valves, but the fingers should always be about 1/16-inch thick to be strong enough to prevent springing open.

Two such tools must be used, one for each side of valve. To install plates, put the largest spring and plate into stop plate and compress, slipping the fingers over on each side; then slip on the next size spring and



Tight, easy valve closure every time after 4 years on 800° F. oil

THE CASE HISTORY—With no maintenance whatsoever in more than 4 years' continuous service, these Crane 300-pound steel gates show no loss of efficiency. Fact is, they look good for service indefinitely.

The installation is at Cities Service Oil Co.'s Ponca City refinery. The valves are on the hot oil outlet lines from a crude unit heater. Oil handled is 800° F.

While operated fairly frequently under high temperature, these Crane No. 33X valves show no effects from this severe service. They have provided tight closure with no leakage at any time—and with unfailingly smooth response to the handwheel.

Outwardly Crane steel valves may look like many others. But there's a big difference inside. For instance, in the extra skill and care that go into Crane Exelloy seating design and manufacture.

That's what makes these Crane valves such outstanding performers in refinery service.

In steel gates, globes, angles and checks, Crane gives complete selection—in sizes up to 24 inches—in pressure classes up to 2500 pounds. See your local Crane Representative for valuable help in specifying and ordering.

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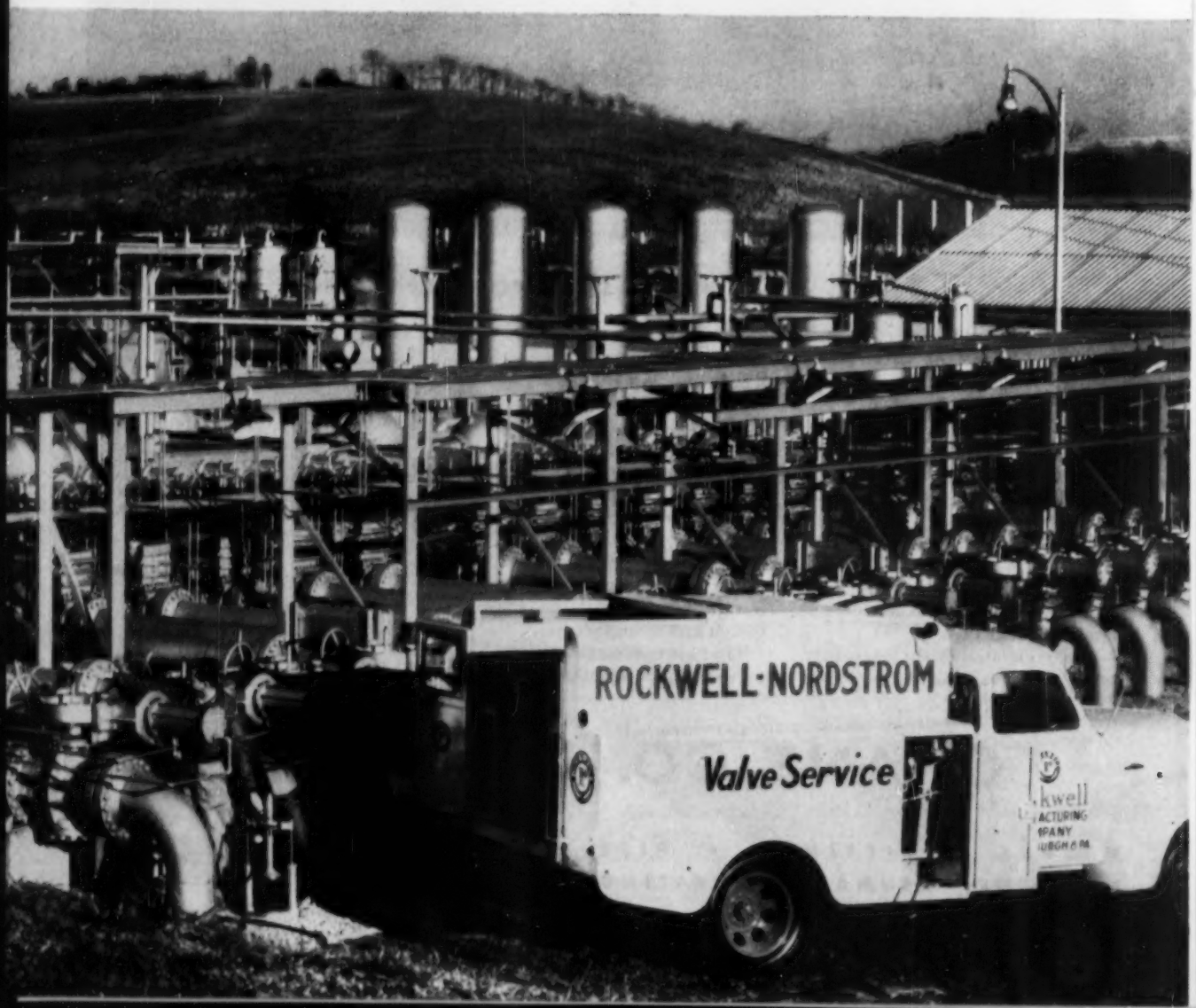
A Mobile Service
For Low Cost
Contracted Valve Maintenance



"Workshops on Wheels"

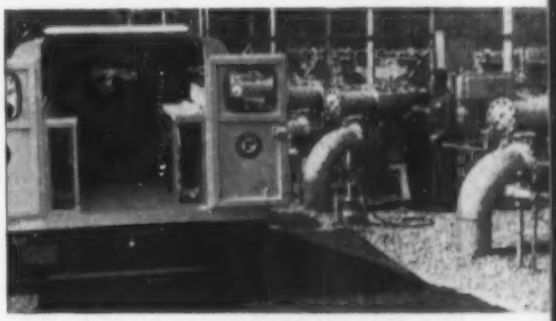
WHAT IT IS: Rockwell's new Mobile Maintenance and Lubrication Service is designed to increase the efficiency and lower the cost of valve maintenance for oil and gas field installations, refineries, pipe lines, chemical plants, and processing plants. It is made possible by a fleet of specially-built valve "workshops on wheels," manned by factory-trained experts, and equipped to provide complete "on the spot" service on a regular schedule, tailored to fit individual needs.

HOW IT WORKS: A Rockwell engineer, thoroughly familiar with Nordstrom valve design and maintenance, as well as with your particular process requirements, studies your installation in terms of its service needs. Then a mutually agreeable schedule is established for the servicing of your valves. From that time on, you have no valve maintenance worries; they become the responsibility of a Rockwell service expert. At regular intervals he will handle all servicing and lubrication quickly, efficiently, working from one of Rockwell's "workshops on wheels." These Rockwell-designed trucks are equipped with the most advanced lubrication, servicing and repair equipment, and built to operate with complete safety under any fire or explosion control requirements.

WHAT IT COSTS: Naturally, the price of this new planned maintenance and lubrication service varies with the size and number of valves, and with frequency of service. Definite prices are established after a Rockwell engineer has studied your individual requirements.

Actually, this new Rockwell service saves far more than it costs. It saves on fixed maintenance overhead. It saves on valve repairs. It saves by reducing costly down time. Because it is expert *preventive* maintenance performed on a regular schedule, it saves by spotting potentially expensive trouble *before* it gets expensive. And, of course, it saves on valve replacement costs because your valves will give you longer, more economical service life.

Pre-planned "on-the-spot" lubrication and service . . .



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The new Rockwell Mobile Maintenance and Lubrication Service is another extra value you can get only from the world's oldest and largest maker of lubricated plug valves. Its sole purpose is to help you get the best possible valve service at the lowest possible cost. For more detailed information, send the coupon below.

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How to Do It . . .

plate until all are held compressed into stop plate by the tool. Put valve seat on and bolt seat and stop plate together, finger tight. Quickly pull out each tool and finish tightening with wrench. Plates are in line without having to move them over to seat properly.

Removable Pipe Rack

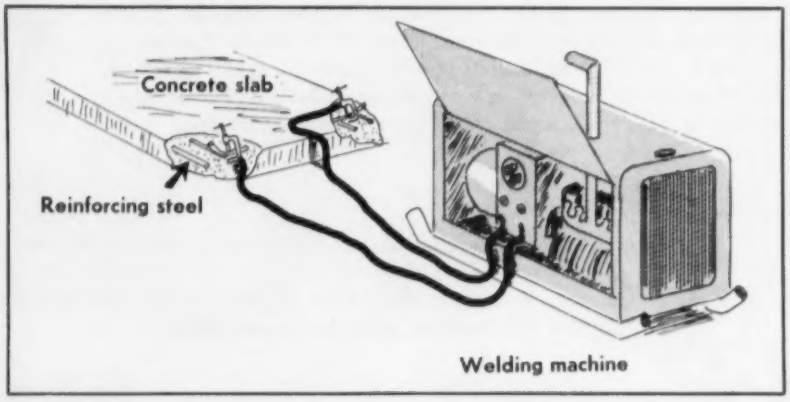
Here is a rack for hauling and working pipe that can be quickly and easily removed from the truck on which it is mounted. The frame is made of angle iron formed so as to fit on the side of the bed of the pickup. It is anchored by clamps.

The adjustable rack is made of 1½-inch pipe telescoping inside 2-inch pipe with matching holes drilled in both. The pipe vise is conveniently located at the back.

Extend Valve Stem for Waist High Operation

Here is a simple means of converting frequently operated valves to waist high operation. To extend the valve stem, first braze together two nuts sized to fit the gate valve stem and weld them to a rod of proper length. Grind a square on the top of the rod to fit the gate wheel. Then screw the extension on tightly and grease the gland so the stem turns smoothly.

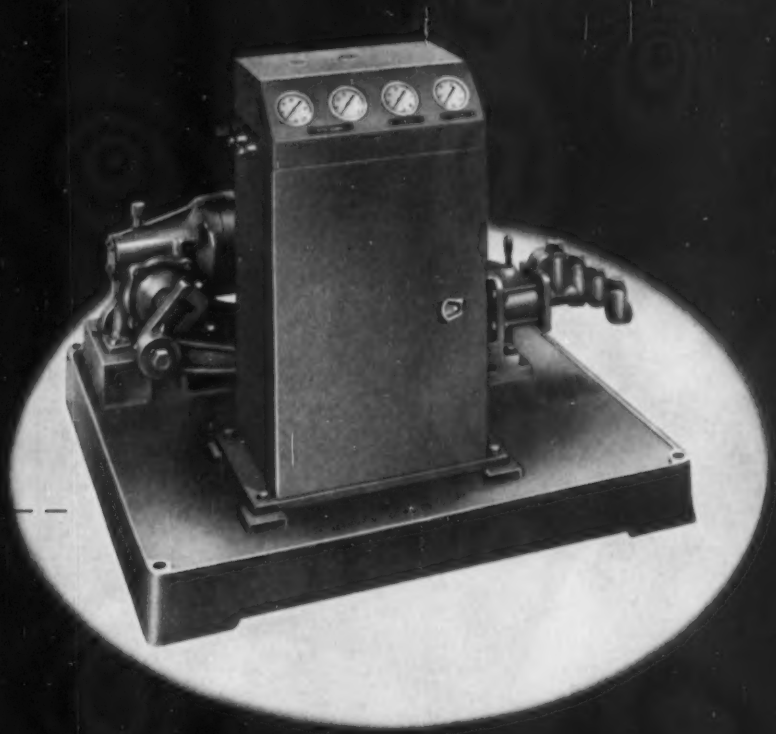
A standpipe is made to fit over the top of the valve as shown. The gate wheel hangs on the standpipe so that it is readily accessible and the cap is locked on when the valve is not operated.



Welding Machine Used to Break Up Slab

To save many hours of labor in breaking up concrete slab during station modification, make use of a welding machine. First chip away enough of the slab to expose the opposite ends of reinforcing steel. Connect the electrodes of the electric arc welder to each end and start the machine. The current through the rod will raise the temperature of the steel

★ *new controlled volume pump*



Milton Roy Motor-Driven Pump with Instrument Air Stroke Length Adjustment. Control cabinet (front) houses components of the stroke-adjusting servo system. Remote capacity control by two process variables is possible when variable speed motor driver is used with pump.

BE SURE TO SEE IT
at the Milton Roy exhibit, "25th Exposition of the Chemical Industries," Dec. 5-9, Convention Hall, Philadelphia, *Booth 313.*

now **automatic stroke length adjustment by instrument air signal**

DESIGN FEATURES

Instrument air	3-15 psi
Main supply air	80 psi
Air consumption:	
Motor running full speed	15 cfm
Motor not running	0.3-0.4 cfm
Motor revolutions per inch change of pump stroke	240
Air consumption per inch change of pump stroke	2.5 cu. ft.
Stroke positioning speed	10 sec./in.
Positioning accuracy	better than 1%
Sensitivity	1/70 psi change in instrument air signal

HERE is precision controlled volume pumping with a *plus:* automatic capacity control by standard 3 to 15 psi instrument air signal. Plunger stroke length is infinitely adjustable from zero to 100% of maximum by an air-operated servo system that is accurate to within 1%. A change in instrument air signal as small as 1/70 psi repositions the plunger stroke length setting.

Heart of this new motor-driven pump is a small, powerful rotary air motor coupled to the stroke-changing mechanism. Air volume boosters in the air motor lines give fast, positive positioning. An extremely stable feedback circuit gives high positioning accuracy. Air consumption, when the system is in balance, is low — only 0.3 to 0.4 cfm.

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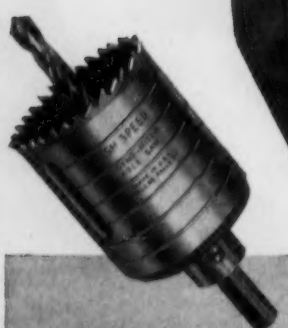

New Millers Falls Deep-Cut Hole Saws
cut through
METAL
PIPE
WOOD
PLASTER
any machinable material

Save time. Save work. These rugged new hole saws will speed up countless jobs for you. With a special *high speed steel* cutting edge welded to a tough chrome-vanadium body, they bite through practically any material.

You can use them to cut into metal pipes and tanks — or for boring holes fast in walls, floors and partitions. They go through wire nails, screws, metal lath and most other metal obstructions without damage to their sharp cutting teeth.

Depth of cut is a full 2½". And, since these saws can follow through the holes they make, you can cut to almost any depth by removing the core as you go along. Good chip clearance, so necessary for rapid cutting, is assured by the spiral elevator groove in the body of the saw.

Get a set of these remarkable new Millers Falls Deep Cut Hole Saws. They come complete in the compact steel carrying case shown above — 6 saws from 1 1/16" to 2 9/16" diameter, plus 2 mandrels with ⅜" pilot drills. Buy yours today. They'll pay you back fast in the time and work they save.

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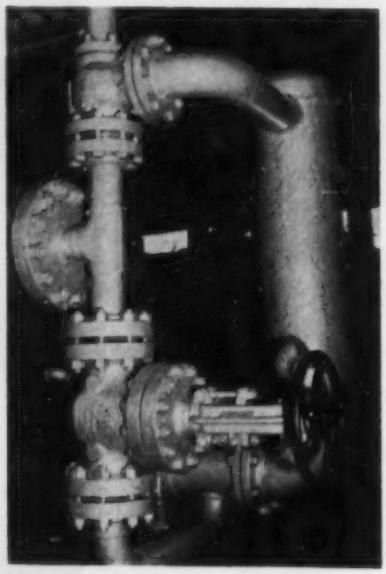
Write for catalog of Millers Falls Tools

MILLERS FALLS COMPANY
Dept. PF-1, Greenfield, Mass.

MILLERS FALLS TOOLS
SINCE 1868

How to Do It...

enough to expand it and cause the concrete to split. By repeating this procedure on through the slab it can be quickly broken up.



System Allows Compressor To Start with Light Load

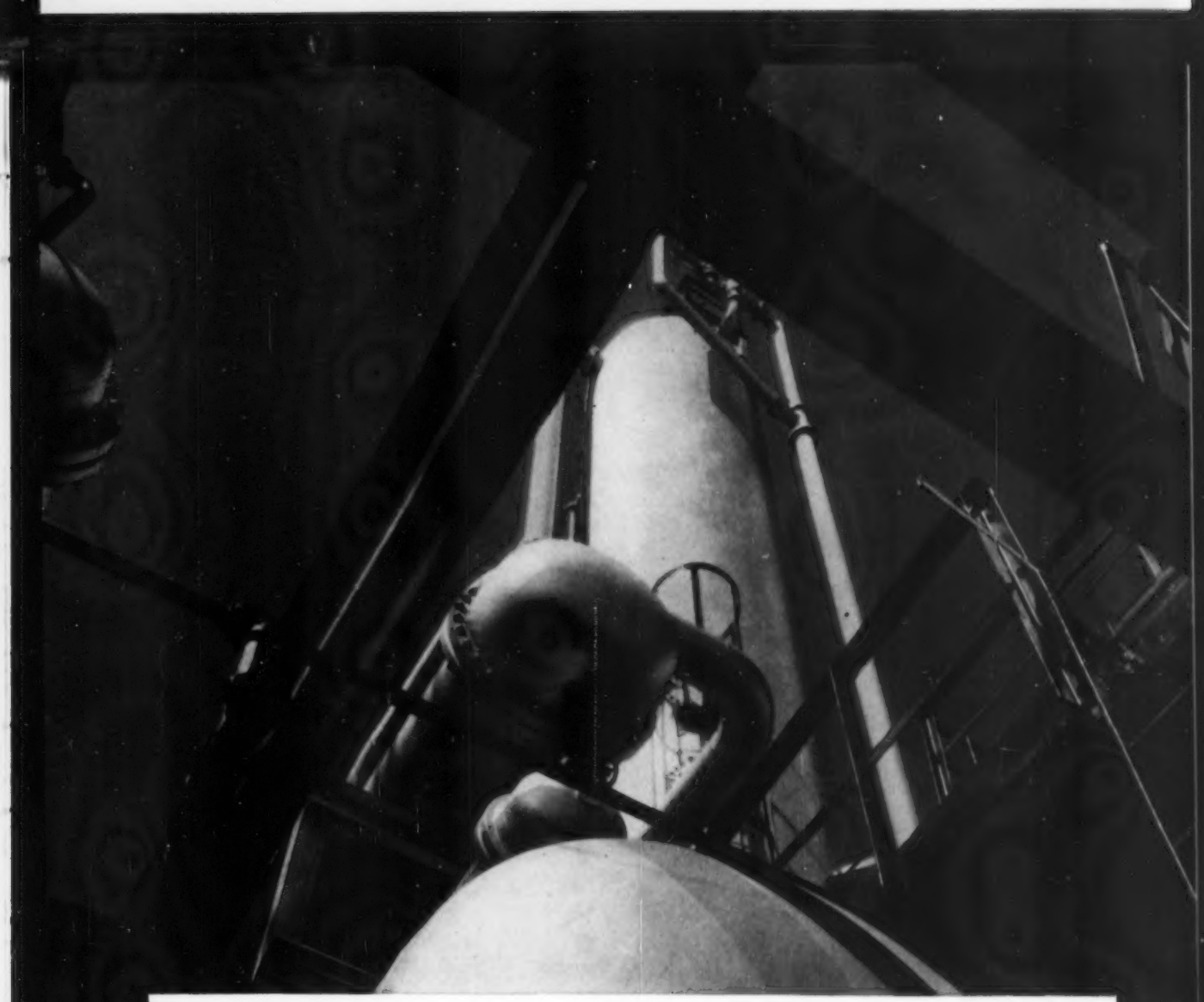
The system shown combines the bypass assembly on a gas compressor with the relief valve assembly.

In operation, the gate valve is opened before starting the compressor, allowing the discharge to flow back into the suction. This allows the compressor to start under low load conditions. This feature is especially desirable in compressors on direct drive from the prime mover where there is no clutch. When the compressor is warmed up, this valve is gradually closed, forcing all the gas out the discharge line.

The system is also tied into a relief valve. If the pressure of the system gets too high, the relief valve also allows flow of the gas from the discharge back into the suction.

Flux May Show Surface Too Dirty to Braze

The left side of the photo shows how flux behaves on an oily steel surface; the section on the right had been cleaned thoroughly and degreased before applying flux. An attempt to braze the surface on the left would probably result in poor wetting of the metal and a mechanically weak and



helpful refinery service that pays for itself!

TRETOLITE DESALTING

is used to desalt over one and one-half million barrels of crude oil daily. Salt removals are in the range of 95 to 100%, with chemical costs averaging around 2 mills per barrel. Regardless of the capacity requirement, Tretolite desalting offers a simple, flexible and economical answer.

OTHER TRETOLITE PRODUCTS AND SERVICES FOR REFINERS

Water Clarification Compounds
Demulsifiers for Waste Oil Emulsions
Demulsifiers for Doctor Treating
Anti-Foam Compounds
Asphalt Anti-Stripping Additives

KONTOL Corrosion Inhibitors

protect internal metal surfaces by forming a protective mono-molecular film. They also offer excellent detergent properties which assure the advantages of operations with clean units. Kontol inhibitors are available in numerous formulas, suitable for use in the various corrosive environments encountered in the refinery.

For complete information, ask your Tretolite refinery service engineer or write to

TRETOLITE COMPANY
A DIVISION OF PETROLITE CORPORATION
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for styrene production

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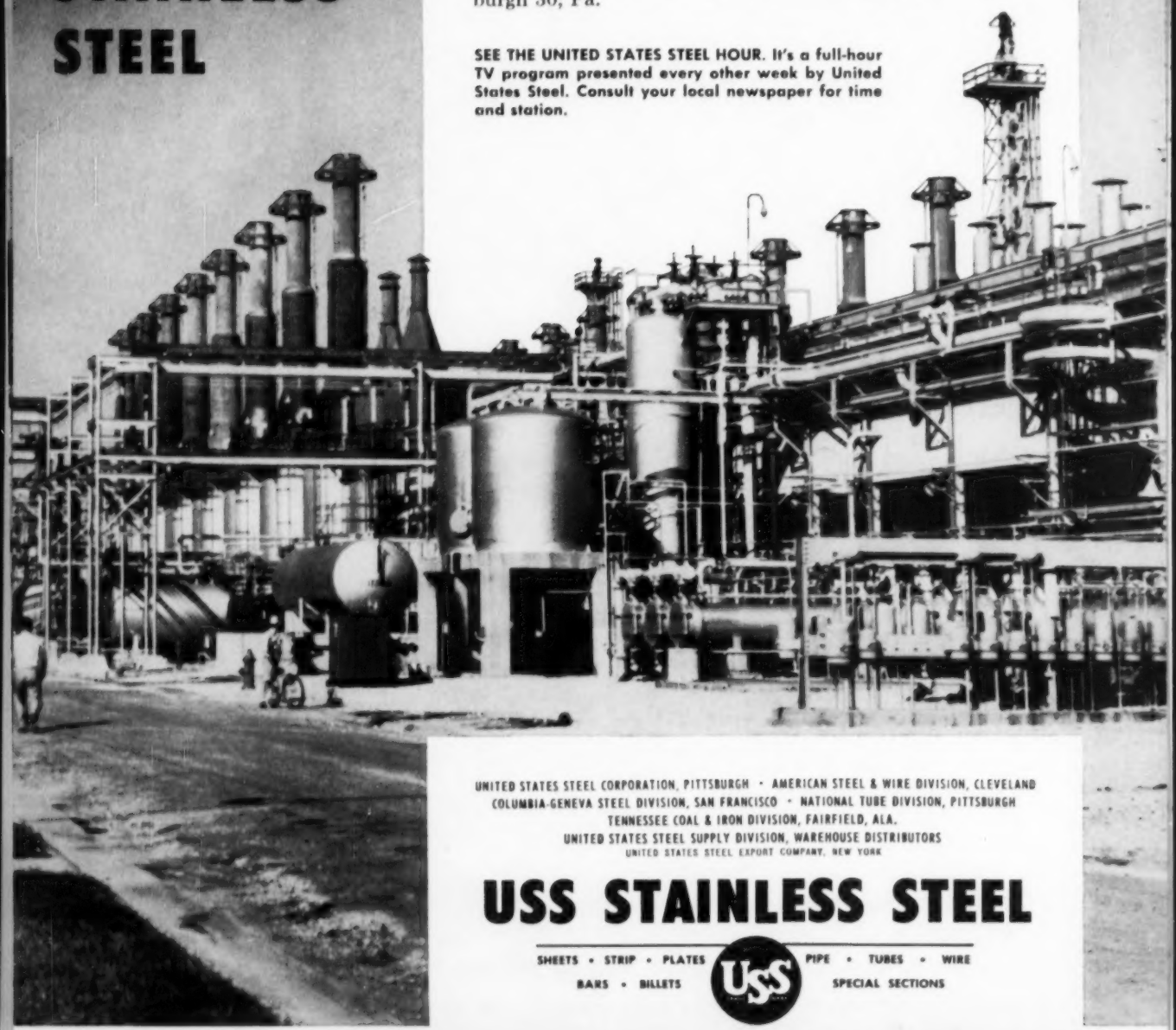
To withstand the conditions that cause corrosion and oxidation in a big styrene plant, Stainless Steel was selected as the material for the tubes in these super heaters.

It's only one of many places where the vastly expanding petrochemical industry has met a problem of heat and corrosion with Stainless Steel. In USS Stainless Steel you have the widest variety of compositions for greatly varying applications. The ways in which USS Stainless Steel has met problems similar to those you may be encountering is described in our booklet "Performance of Stainless Steel in Petroleum Refinery Service." For your copy, write to United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



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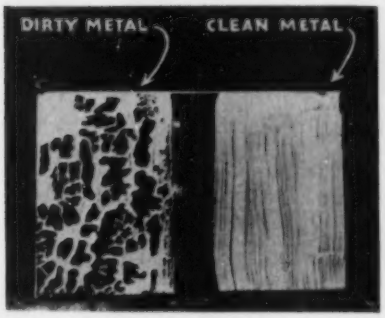
UNITED STATES STEEL

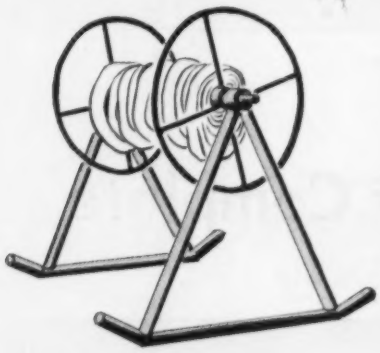
How to Do It...

leaky joint. If flux wets poorly, the most economical thing to do is to clean and degrease before brazing.

To clean, first use a vapor degreaser or solvent. Then remove any oxide by

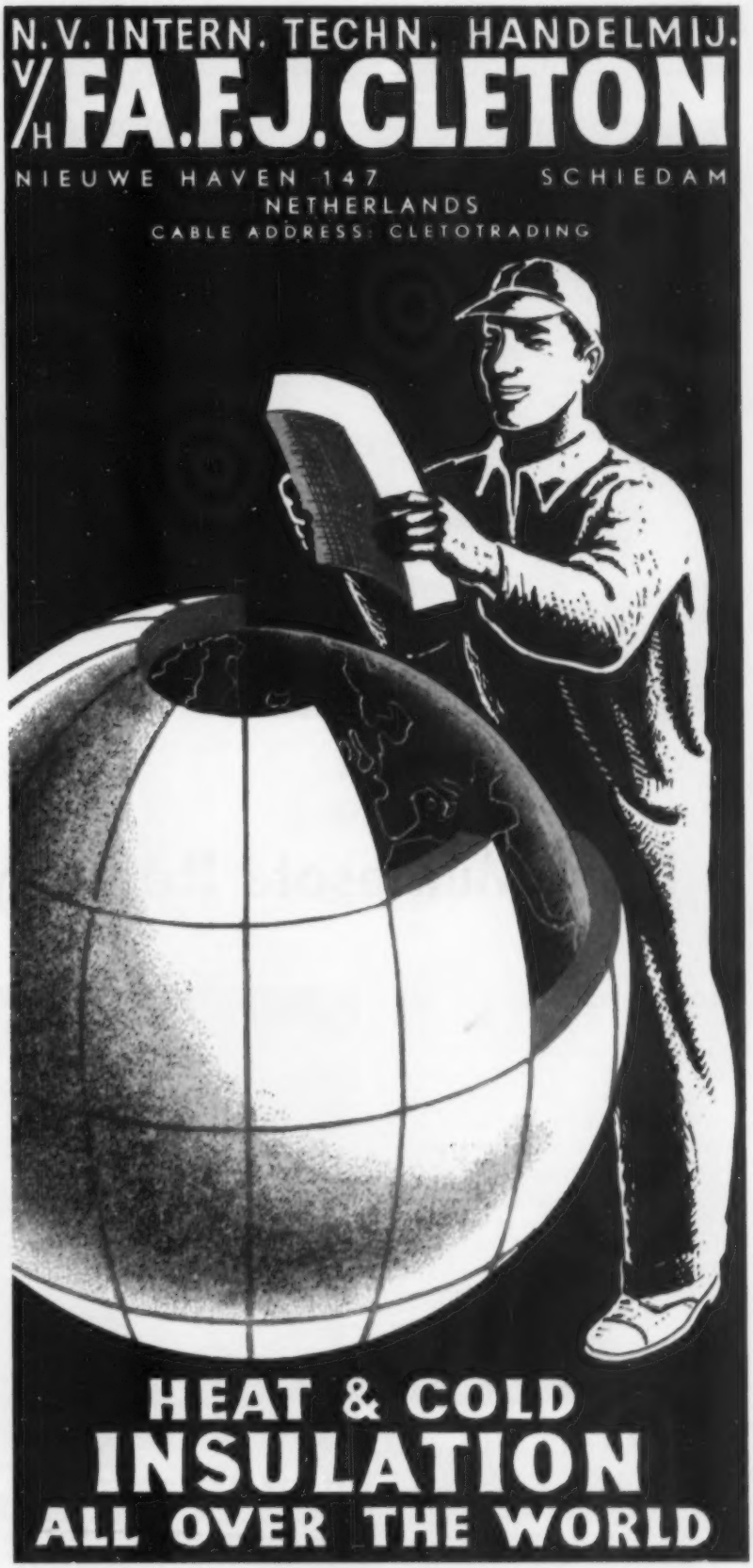


pickling or by using an abrasive wheel or belt. After cleaning be careful, too, not to touch the joint faces. A greasy fingerprint can do as much damage as a patch of oil.



Use Scrap Materials To Make a Hose Reel

This handy all-metal hose reel was made entirely from scrap materials found around the machine shop. The spool of the reel is made by welding a framework of small rods around a central member made of 3-inch pipe. In this case, the wheels located at each end of the spool were also made by shaping small diameter rods. The supports are constructed from 1-inch pipe. This pipe is welded into the form of two triangles, with one side of the triangle resting on the opposite tip of the triangle attached to a 1-inch pipe which runs down the center of the 3-inch pipe in the spool. Braces are welded between the side supports to give the framework the desired rigidity.



For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Great Northern Oil Company goes on stream at Pine Bend.

New Minnesota Refinery Complete

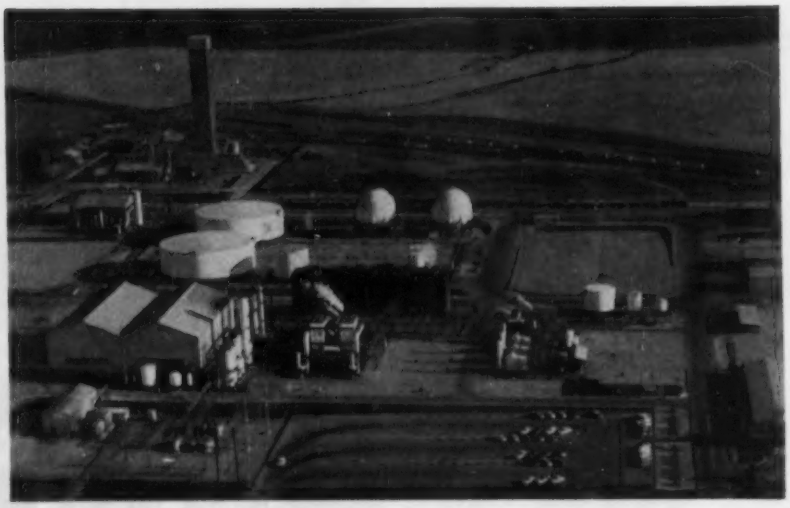
MINNESOTA'S largest oil refinery is now on stream at Pine Bend. Process equipment at Great Northern Oil Company's new 25,000-barrel-a-day refinery includes:

A crude-distillation and tar-separation system, a Thermofor catalytic cracker, hydrodesulfurization and Ultraforming units, catalytic polymerization facilities, a gas-recovery unit and delayed coker.

The first unit to go into operation was the refinery's two-stage crude unit, separating crude into light and heavy naphthas, fuel oil and reduced crude.

Products from the crude unit were moved to other units as they were ready to start up. The light overhead fraction goes to the cracking unit where it is split into gasoline and fuel oil; reduced crude is pumped to the coking unit.

The second piece of equipment to



New Tower on the Horizon—

The 200-foot prilling tower, upper left, at the new Brea Chemicals, Inc., ammonium-nitrate plant near Brea, Calif., is the tallest all-aluminum process structure in the world. Sprayed as droplets into the top of the new aluminum tower, liquid ammonium nitrate cools and solidifies as it falls, forming uniform prills. The company, a subsidiary of Union Oil Company of California, built the plant at a cost of some $3 million. It has a daily capacity of 137 tons.

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Who's Building...

start was the catalytic-cracking tower. Further processing and treating are done in the treating units before they are blended with products of the next refining stage.

The refinery will turn out more than 500,000 gallons a day of gasoline, plus both No. 1 and No. 2 fuel oils, propane, butane, petroleum coke and sulphur.

The refinery was engineered and constructed by The Fluor Corporation, Ltd. Great Northern will operate the plant under licenses on the Thermofor catalytic cracker, hydrodesulfurizer, Ultraformer and catalytic polymerization unit from Socony-Mobil Oil Company, Standard Oil Company (Indiana), and Universal Oil Products Company.

Purvin and Gertz, a Dallas engineering firm, served as consultants on the project, and The Lummus Company was retained in its early stages to establish the type of process units and product specifications to be used, and to assist in selecting a site.

Union Oil Company of California has started a project to double the capacity of its recently completed Santa Maria, Calif., sulphur plant. Construction at the plant, which was built in connection with a new coking plant, will increase its capacity to 84 tons a day. The project, due to cost $760,000, includes work to control air pollution.

Phillips Chemical Company will expand by 22 percent the rubber-making capacity of its Borger, Texas, copolymer plant. The company already had announced plans to expand general plant facilities by 15 percent. The plant's present capacity is 63,000 tons a year.

Production of an adjacent butadiene plant will be stepped up to provide additional butadiene for the copolymer plant. Construction will begin immediately, with completion scheduled for early 1957.

International Petroleum (Colombia), Ltd., with long-standing plans to build a refinery near Cartegena, has selected Bechtel Corporation to handle construction on the Colombian project. The plant, designed for a daily capacity of 25,000 barrels, is scheduled for completion late in 1957. Its cost originally was expected to run some $35 million.

Raffinerie Siciliane Olii Minerali is expanding the annual capacity of its Augusta, Sicily, refinery by 650,000 tons to 2,150,000 tons. Rasion plants refine crude oil from the Middle East. The Augusta refinery was originally a U. S. plant. It was dismantled and shipped to Italy in 1949.

E. I. du Pont de Nemours & Company will build a plant to manufacture a chemical rubber at Beaumont, Texas. The product will be a chlorosulfonated polyethylene developed by Du Pont research. The new plant is scheduled for completion during the first part of 1957. Additions and alterations to the company's existing power and service facilities at Beaumont also will be started.

Monsanto Chemicals, Ltd., will build a new phtalic-anhydride plant at Newport, Monmouthshire, U. K. Due to cost $1.4 million, the plant will be in production by late 1957. It will be built for an annual capacity of 15,000 tons.

Seven New Write-Offs Granted

Office of Defense Mobilization, moving to clear a backlog of eligible applications under its new rapid-fast write-off program, has issued seven new certificates of necessity for refining projects.

Meanwhile, applications for fast write-offs continued to be filled with the agency, despite its newer and tougher rules covering amortization. Almost $70 million worth of refining facilities are covered in new applications.

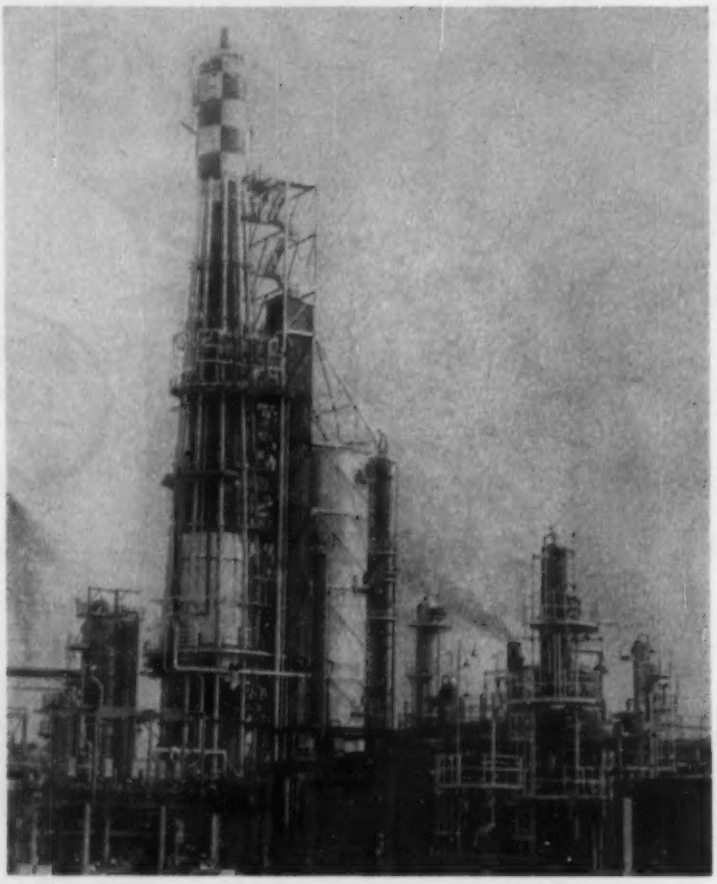
The largest of these projects are two for Standard Oil Company (Indiana), totaling $19,589,000 and $6,820,000. The applications apparently cover facilities to replace and supplement equipment damaged or destroyed in the fire at Whiting, Ind.

The next largest refining facility covered by an application for fast amortization totals $11,303,000. The application was filed by Esso Standard Oil Company. Others filing applications:

Gulf Oil Corporation, $3,222,500; Pontiac Refining Corporation, $1,983,000; Bankline Oil Company, $1,962,000 and $608,000; Houdry Process Corporation, $151,000, and Cosden Petroleum Corporation, $137,000 and $1,100,000.

Also, Prime Oil Company, $13,423,235; Cities Service Oil Company, $8,914,000;

Petrofina Goes On Stream



Canadian Petrofina, Ltd., has gone on stream with a 16,000-barrel-a-day catalytic cracker at its recently completed refinery in Montreal, Que. The refinery was designed for a daily thruput of 20,000 barrels.

Charge to the cracker, the tallest Houdriflow catalytic cracking tower ever built in Canada, is light and heavy gas oil from the refinery's vacuum distillation unit. Later the charge will include gas oil from the plant's coking unit.

Of the total charge to the 285-foot cracker, 10,000 barrels a day will be fresh feed, with the remaining 6600 barrels a recycle stream, heavier than diesel oil.

In addition to the refinery's vacuum distillation unit, the cracker and future coking unit, other major process equipment at Montreal include catalytic reforming, catalytic polymerization and alkylation. Anticipated high yields of isobutane and butylenes, in addition to high-octane gasoline, make alkylation attractive.

Construction was handled by The Lummus Company Canada, Ltd., and Canadian Kellogg Company.

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Who's Building...

The Texas Company, $116,000; National Cooperative Refining Association, $1,400,000, and The Atlantic Refining Company, $89,270.

Miami Oil & Refining Company was issued an amended certificate of necessity, changing the location of its proposed Florida refinery from West Palm Beach to Fort Pierce. Other companies receiving certificates:

Petrolite Corporation, El Paso, Texas, refinery facilities, 60 percent on $21,800.

Sunray Mid-Continent Oil Company, San Patricio County, Texas, natural-gasoline facilities, 25 percent on $269,000 and 65 percent on $3,241,000.

Esso Standard Oil Company, Sorrento, La., underground storage, 40 percent on $979,500.

The Carter Oil Company, Billings, Mont., oil-refining equipment, 45 percent on $412,750 and 65 percent on $1,384,250.

Sunray Oil Corporation, Acadia Parish, La., natural-gasoline facilities, 40 percent on $163,000 and 65 percent on $1,181,000.

Utah Oil Refining Company, petroleum refining facilities, 40 percent on $441,000 and 65 percent on $2,097,500.

International Refineries, Ltd., refinery equipment, Wrenshall, Minn., 40 percent on $538,450 and 65 percent on $850,000.

Standard Oil Company of California, planning to build a 25,000-barrel-a-day refinery at the entrance to Honolulu harbor, has offered to put up a plant which will produce neither smog, pollution nor odors.

The offer, made in a plea for a change in zoning ordinances to permit construction of the $30-million refinery, was conditionally accepted by the city's planning commission. The conditions allow company scientists 60 days in which to furnish evidence that they could build a refinery which would have no effect on plant life, animals or fish.

The company's plans were opposed by local groups which hope to see the site developed as a park. The land is controlled, however, by the U. S. government, which has agreed to release the land only if it is used as the location for a refinery.

Process facilities would include a two stage crude-distillation unit, a 10,000-barrel-a-day fluid catalytic cracker and a 1000-barrel-a-day alkylation plant.

Anti-pollution equipment would include a hydrogen-sulfide-recovery unit, to prevent escape of odors from refinery fuel gas; a closed system, to gather and return to the system all vapors released through safety valves; incineration of all flu gases from the catalytic cracker; electrostatic precipitators which would remove escaping catalyst dust from flu stacks; storage tanks which would be provided with floating roofs, to prevent evaporation; mechanical seals on all pumps, as a precaution against vapor loss, and separators used to remove contaminates from all liquid waste before it is discharged into the ocean.

Reichhold Chemicals, Inc., is due to start construction of a 100-ton-a-day sulfuric-acid plant at Tuscaloosa, Ala. The new facility is due for completion in March 1956.

The project, with auxiliaries, will represent an estimated investment of nearly $1 million. Output of the new plant will be used by the company in its manufacturing program.

Salle de Controle—

European refineries are fast adopting the latest technological advances. Shown is a view of the control room at the Societe Industrielle Belge des Petroles of Brussels. The colorgraphic control panel is believed to be the first of its kind to be used in a European refinery. Designed by Minneapolis-Honeywell engineers, the panel and control system for the Belgium refinery covers a catalytic cracking and polymerization unit. It was constructed by the French subsidiary of The Lummus Company. The S.I.B.P. refinery is one of Belgium's largest.

Badische Annilin und Soda Fabrik is building a chemical plant in Turkey. The plant, to be ready at Kutefia in 1958, will turn out 60,000 tons of ammonium sulfate a year, 50,000 tons of sulfuric and nitric acids and 10,000 tons of ammonium nitrate.

Rohm & Haas, GmbH, Chemische Fabrik has brought on stream a new acetone-cyanhydrin unit at Darmstadt, Germany. The plant is using natural gas as raw material. The company is considering further expansion in the petrochemical field.

Petro-Tex Chemical Corporation has let the contract for construction of new facilities which will expand the output of its Houston butadiene plant by about 50 percent. The contract went to Bechtel Corporation. The plant, acquired from the government, now has an annual capacity of 90,000 short tons.

In addition to expanding its producing facilities, the company plans an addition to its process-research laboratory and pilot plant facilities, as well as an enlargement of its plant offices. Work will begin immediately, and the new units are expected to be completed by the end of 1956.

U. S. Industrial Chemicals Company has completed a new pilot plant building on the site of its other research facilities in Cincinnati. The company, a division of National Distillers Products Corporation, will share the building with the affiliated National Petro-Chemicals Corporation.

The new structure provides facilities for final testing of processes and products developed in the research laboratories. The first product to be piloted in the new research building will be isosebacic acid.

Benzin und Petroleum, GmbH, has started construction on a 5700-barrel-a-day Hydrofiner for desulfurizing diesel oil at its 28,000-barrel-a-day Hamburg refinery. The unit, to use hydrogen from the refinery's 5000-barrel-a-day catalytic reformer, is the second hydrofiner due to be built at British Petroleum Company, Ltd., refineries this year. The other unit, with a capacity of 8000-barrels a day, will be erected at the company's Kent, England, refinery.

Hercules Powder Company is starting construction of a new plant at Louisiana, Mo., to produce pentaerythritol. The plant, to cost about $6 million, is scheduled for completion in late 1956. It will double the company's pentaerythritol capacity. The new facility will turn out 24 million pounds of pentaerythritol a year and 100 million pounds of formaldehyde.

Phillips-Pacific Chemical Company has selected Pasco, Wash., as the site for its proposed 200-ton-a-day ammonia-fertilizer plant in the Pacific Northwest. The company, recently formed by Phillips Chemical Company and Pacific Northwest Pipe Lines Corporation, expects to have construction underway by spring 1956, with the $12-million plant scheduled to start operations late that year. Phillips Chemical has started design work at Bartlesville, Okla.; Fish Engineering Company will handle construction and mechanical work.

Neste Oy, Finnish state-owned oil company, has asked firms in France and Germany to furnish equipment for the new 18,000-barrel-a-day refinery it is building at Turku. A French concern, Compagnie de Vies-Lille, will provide about 60 percent of the plant facilities, and the balance will be sent by Mannesmann Rohrbau, a German supplier. Some special equipment

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

WORLD PREMIERE . . .

1955 Chemical Show sees debut of several New Achievements in Glassed Steel Construction

No contamination, no leakage with new seal for reactors

No metallic contamination of your product. No stray, unwanted catalysts. No escaping vapors.

These are the advantages of a new nonmetallic rotary Crane-type seal now available on Pfaudler glassed or stainless steel reactors up to 100 gallons. (A similar design is also available for larger units.)

Only Pfaudler glass, Teflon, ceramic and carbon come into contact with your product. Design of the seal is simple, easily maintained.

New development boosts corrosion resistance of columns

Better results from fractionation and other processes requiring a column are now possible with the added corrosion resistance of a new Pfaudler development.

It's a glassed steel distributor plate, available for all size columns. Using Pfaudler acid-alkali-resistant glass, this plate provides complete flexibility of use over a range up to pH 12 at 212° F.

The corrosion resistance of this glass protects product purity, simplifies cleaning, and protects your equipment investment.

Dryer-blender tumbles out 4 days' work in 7 hours

In actual use, a Pfaudler glassed steel conical dryer-blender is producing as much dried product in 7 hours as formerly required at least 4 working days, using a different type of dryer.

Double-cone shape, tumbling action and efficient heating design are responsible for this great speed. In addition, a broad range of corrosive applications is possible, because the unit is fabricated of Pfaudler's special acid-alkali-resistant glassed steel.

To pre-test your product in the Pfaudler dryer-blender, a small 2′-

diameter test model is available. You'll see it at the Chem Show – or write us for full details.

New Pfaudler hydraulic drive and seal

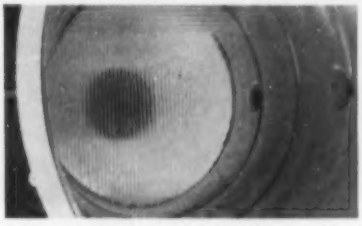
The new Pfaudler hydraulic drive and seal offers many advantages: It can be made in both stainless steel and glassed steel construction for a large range of reactor sizes and for greater horsepower requirements with either hydraulic or air motors.

Any noncorrosive fluid can be used as a seal – even one of the ingredients of your own product – providing you 100% protection against contamination.

This seal is operated under pressure, requires a minimum of maintenance, and is designed to give years of trouble-free service. Your Pfaudler representative can provide full details at your request.

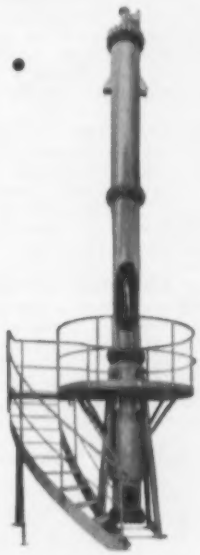
New Turbogrid tray gives higher yield at lower cost

You're looking down the throat of a Pfaudler glassed steel Turbogrid



column, at a new tray design that provides enormously high capacities, yet lowers the cost of the column itself.

The tray is constructed of high-strength PYREX brand glass tubes,



Cutaway column, providing an unusual view of the "business side" of Pfaudler glassed steel construction, is a feature attraction at Chemical Industries Exposition, Philadelphia.

with all their inherent advantages of corrosion resistance, physical toughness, and thermal shock resistance.

Because of the high capacity resulting from this design, the column itself can be of smaller diameter than previously required – an important means of cutting its cost.

Now—variable agitator speeds ranging from 60 to 340 RPM

Six different agitator speeds: 60, 90, 120, 175, 250, and 340 RPM are now available on Pfaudler reactors up to 100 gallons.

These are made possible by interchangeable constant-speed sheaves of the new PW drive. As an alternative, variable pitch sheaves may be supplied, giving quick adjustment for *all* speeds ranging from 60 to 300 RPM.

The new PW drive rides high above the top head of the reactor, out of the way so you can have easy access to other nozzles.

Write for Bulletin 923.

Which material of construction for you?

Glassed steel, stainless, titanium, Inconel, Hastelloy, copper and copper alloys, and many other corrosion-resistant materials are commonly used by Pfaudler to solve processing problems. Write today for free, unbiased analysis of *your* problem.

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building. . .

also will be bought in the U. S.

Three U. S. companies have licensed Neste Oy to use their processes. Refining equipment will include Socony Mobil Oil Company's catalytic-cracking process; catalytic reforming developed by The Atlantic Refining Company and California Research Company's polymerization processes. A contract to build the plant, to be the world's northernmost refinery, earlier had gone to The Lummus Company, which also will handle the engineering.

Sioux Oil Company will build a 750-barrel-a-day catalytic reformer at its Newcastle, Wyo., refinery. Process design for the unit, a Houdriformer, was furnished by Houdry Process Corporation. Engineering and construction is being handled by Litwin Engineering Company.

The Dow Chemical Company has started commercial production of soda ash at a new $3-million plant at Freeport, Texas. The plant, built to turn out 300 tons of the product a day, is the second new Dow installation in the Freeport area. The company recently completed an $18 million polyethylene plant.

Socony Mobil Oil Company, Inc., will begin construction of a $600,000 building at Paulsboro, N. J., to house the chemical, radiochemical, physical and other analytical operations of its Research and Development laboratories.

The new laboratory will nearly double the company's space available for analytical operations in petroleum research. Plans call for the installation of the newest types of analytical equipment.

Gonzalez Chemical Industries, Inc., building Puerto Rica's first chemical plant at Guanica, Puerto Rico, will make anhydrous ammonia, ammonium sulfate and sulfuric acid. The plant, which will turn out 115 tons of ammonia a day, is being built by The Lummus Company, with Cox & Weinrich handling the engineering. The plant was due to cost $12,500,000.

Aurora Gasoline Company has gone on stream with a new 600-barrel-a-day Unifining unit at Muskegon, Mich., processing cracked distillates and naphthas to produce part of the feed stock for a Platforming unit. Process design for the Unifiner was done by Universal Oil Products Company, which also licensed the installation. Aurora personnel handled the engineering and construction work.

Hercules Powder Company will build a plant at Parlin, N. J., for making a new high-molecular-weight polyethylene. The plant, with an annual capacity of some 30 million pounds, eventually will cost about $10 million. The project will include conversion of existing facilities at Parlin.

Cabot Carbon Of Canada, Ltd., will expand its Sarnia, Ont., plant to increase production of oil-furnace carbon blacks from 20 million pounds a year to 55 million pounds. The project is due for completion early in 1956.

Shell Chemical, Ltd., has brought its $2-million epoxy-resin plant at Liverpool into full production. The new installation, designed by Shell engineers, has an annual capacity of 2000 tons.

Building a Refinery—

Construction on an Orthoflow fluid catalytic cracker is underway at the 130,000-barrel-a-day refinery Tide Water Association Oil Company is building near Delaware City, Del. To the left is the skirt of the unit's converter column. The octagonal structure beside it is the foundation for another part of the catalytic unit. In the foreground are sections which derricks will hoist to the top of the converter skirt to complete the 350-foot column.

Surpass Petrochemicals, Ltd., is building a plant at Scarborough, Ont., to make Canada's first petroleum sulfonates and synthetic sulfonates. The plant will start production early in 1956.

Bitumen & Oil Refineries, Ltd., plans to build a new refinery at Brisbane, Australia. The plant, ultimately to have a capacity of 10,000 barrels a day, will cost $3,360,000. The company already operates a 6500-barrel-a-day refinery at Brisbane, in which it has invested $1,120,000.

New construction will include a 10,000-barrel-a-day atmospheric-distillation unit, a Platformer for 900 barrels a day, and a 2300-barrel-a-day catalytic hydrogeneration unit. The new refinery will go on stream by June 1957.

Petroleos Mexicanos has completed a $14,800,000 expansion designed to increase the capacity of its Minatitlan, Vera Cruz, refinery to 25,000 barrels a day. In addition to gasoline, both high-octane and ordinary, the refinery will produce kerosine and industrial gas. Plant improvements include new primary distillation facilities, a 25,000-barrel-a-day salt-removing unit, a vacuum-distillation unit, catalytic cracker and other equipment.

Consumers Cooperative Association is nearing completion on a $250,000 catalytic reforming unit at its Scottsbluff, Neb., refinery. The new unit is expected to increase the plant's octane rating for regular gasoline from 85 to 90 numbers. The refinery has a daily capacity of 2200 barrels.

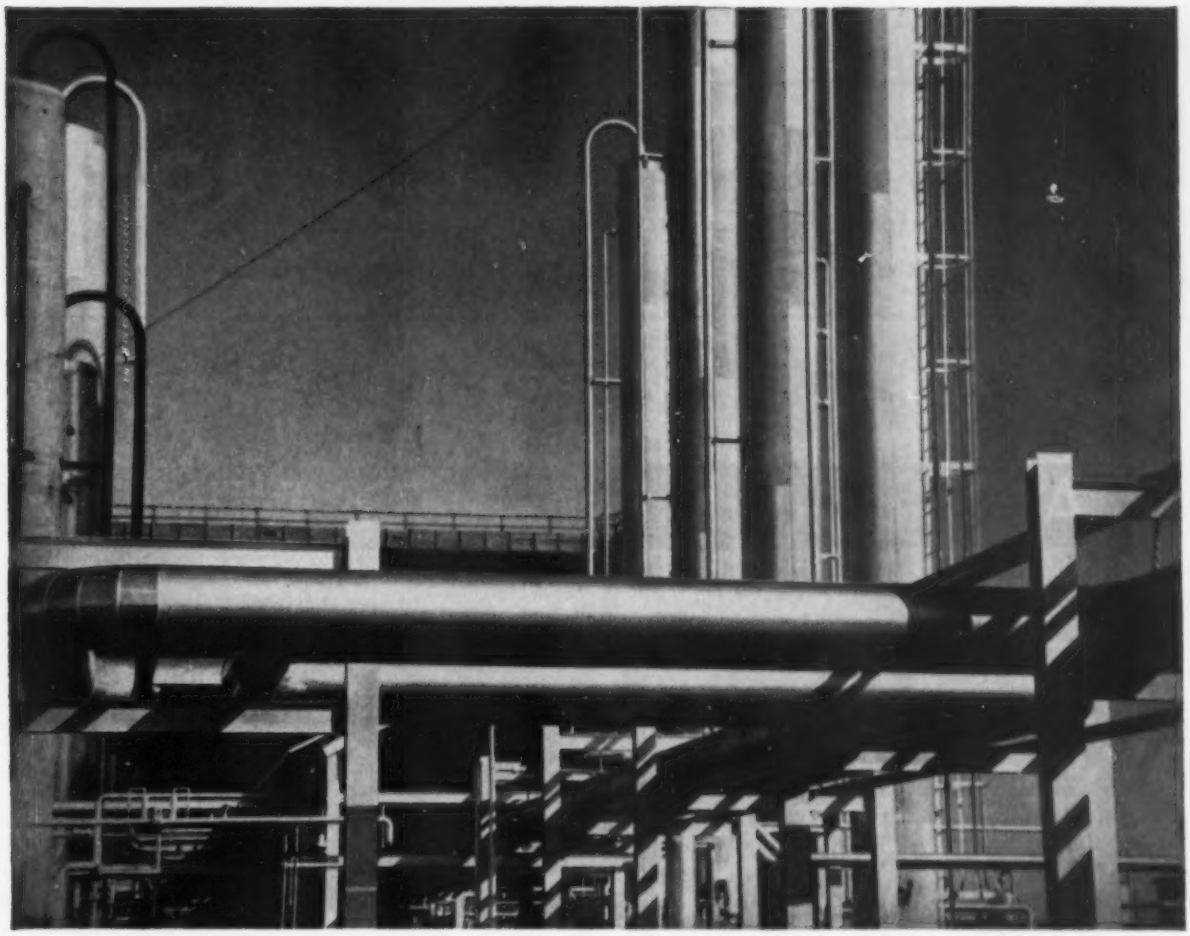
Esso Standard Company, Ltd., has a $2.8-million expansion program underway at its Abingdon, England, research laboratories. The project will include the installation of new engine-testing facilities, analytical, inspection and research laboratories, and a new office building.

Imperial Oil, Ltd., planning to build a new wax plant at its Sarnia, Ont., refinery, has awarded The Fluor Corporation of Canada, Ltd., a contract for construction of most of the $4.5-million project. The company already had selected Fluor to build a 13,500-barrel-a-day catalytic reformer at Sarnia.

The contract also includes a new hydrofining unit which uses a new process developed by Imperial for production of waxes and lubricating oils. Construction is due to start early in 1956, with the plant scheduled for completion by October 1956. It will have an annual capacity of 35 million pounds of wax.

The company also has opened its $13-million lubricating-oil plant at Edmonton, Alta. The plant was built for a daily capacity of 2000 barrels. Canadian Kellogg Company handled construction, and Kellogg joined Imperial's Edmonton staff in engineering the project.

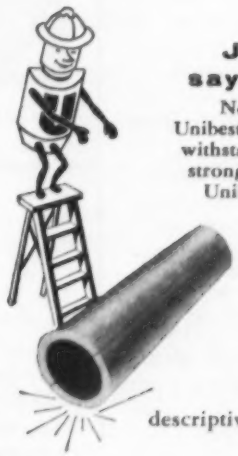
Yugoslavia has a refinery under construction in the Makaraska district of Dalmatia, to process crude oil from the Dalmatian Islands. The country recently completed an expansion of its largest refinery, at Sisak, increasing the plant's annual capacity to 250,000 tons. Annual refining capacity of Yugoslavia is now capable of turning out 780,000 tons a year, with production scheduled to reach 950,000 tons by the end of 1956.



Single-layer Unibestos gives greater protection against heat loss

Here's a single-layer pipe insulation that cuts heat loss at the joints more effectively than many double-layer insulations. Made of Amosite, the quality asbestos with long, interlacing fibers, Unibestos provides greater insulating economy in refinery operations. Single-layer construction makes Unibestos easy to apply to all types of fittings for faster, lower cost installation.

Built for durability, Unibestos resists moisture, steam, acid and chemical fumes . . . withstands shock without shattering . . . is easily removed, re-used or adapted to meet changing needs. Unibestos® pipe insulation is available in sectional form through 44" O.D.



Joe Bestos says:

No shattering here! Unibestos pipe insulation withstands shock. Built strong to stay strong, Unibestos gives you *extra* durability.

Write for **Free** descriptive Bulletin 109C.

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Reliable studies show that most companies have . . .

- **Many employes whose mechanical information is not used**
- **Few clerical employes with both speed and accuracy**
- **Many extroverts . . . a trait useful in supervision**

Are You Hiding Employe Talent?

Eugene J. Benge,
Benge Associates, Asheville, N. C.

Few oil companies make full use of their employe talent. In fact, chances are high that of 100 employes selected at random, at least three could qualify for higher tasks.

In companies where no organized plan of internal selection has been at work, the figure may be much higher. It may be lower in oil production field crews, higher in refineries, much higher in administrative and marketing organizations.

Attitude surveys reveal that at least 80 per cent of employes are unhappy about the opportunity picture they see. "This outfit doesn't know I'm alive," they complain. Or perhaps, "They always bring in outsiders to fill the worthwhile vacancies."

All the while, union contracts are being written with seniority clauses to limit choices for promotion, length of service clauses to determine pay increases.

Employers are caught on a three-horn dilemma of scarcity, opportunity and seniority. Not to mention the constant cry for more engineers, more chemists, more technicians. And technical school enrollments suggest that the condition will worsen in the years ahead.

A "search for talent" with proper followup can relieve, perhaps even solve, this dilemma.

A Continuing Program

The basis of the program is the proven fact that there is unused talent in the ranks. The program sets up devices to uncover this talent, generally in some such order as the following:

1. A search for talent.
2. Interviews.
3. Adequate personnel records.
4. Merit rating.
5. A talent file.
6. Proper promotion policies.

Any company which has already developed certain portions of such a program is in a favored position to add the others, to form a completely integrated program of internal selection based on ability. Few companies can hope to fill all their needs for key men by means of the devices here outlined, but every company can offer to ambitious employees the assurance that there is at work a fair and adequate system of internal promotion.

By locating men and women capable of filling such jobs as inspector, subforeman, production clerk or laboratory tester, pressure is relieved on higher supervisory or technical levels. By providing objective ways to gauge merit, presure is relieved on the deadening lockstep of seniority as the main or sole determinant of promotions.

Basically, the search for talent is an aptitude testing program. Employes are invited to volunteer for it; there is no compulsion. It is carefully explained to supervisors (who them-

Meet the Author

EUGENE J. BENGE has been engaged in the various aspects of personnel management since 1918. He has handled personnel research at Carnegie Institute of Technology; served as industrial-relations manger for both The Atlantic Refining Company and American Oil Company, and conducted lectures under the auspices of several universities. Since 1939 head of his own firm of Chicago management engineers, Benge conducts aptitude tests, morale surveys, job evaluations, merit ratings and other probes in management problems.

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COLD NIGHTS...

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ADDING WARREN NATURAL GASOLINE TO YOUR PRESENT HIGH QUALITY MOTOR FUEL WILL GIVE IT THE

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As Management Sees It . . .

The ideal internal selection program should include . . .

- **A comprehensive application blank designed to analyze experience, schooling, and physical status.**
- **A history card system to record job and rate changes after employment; also suggestions, accidents, periodic physical examinations, added study, etc.**
- **A merit rating program.**
- **Aptitude tests . . . at first for applicants, later for promotions and transfers or periodic talent searches.**
- **Periodic interviews and specialized training for those in the talent file.**
- **Adequate promotion policies.**

selves may volunteer) so they will encourage worthwhile employes to take advantage of the opportunity, and can answer questions about the plan. It is also outlined in notices to employes and played up in the employe paper.

Usually from 5 to 30 percent of employes will submit their names—the lower figure in industrial organizations employing many girls, the higher figure in office or financial organizations. For a refinery, 10 to 12 percent would be a good showing.

Case Study

Typical of procedure and results was the survey conducted in the Morgan Manufacturing Company of Black Mountain, N. C. This concern has a working force of 450 employes, almost all males.

Tests were given in the cafeteria. Sometimes a conference or assembly room is available for this purpose.

In the Morgan study, because of shifts, it was necessary to administer the basic tests in morning and afternoon groups. It is preferred that all volunteers take the three basic tests at the same time, when possible.

The three basic tests were—

1. A ten minute interest test, revealing whether a person desires to work with
   a. People
   b. Ideas
   c. Mathematics
   d. Physical objects

There are no right or wrong answers to this simple test and it is used as a "shock absorber."

Typical question:

Which of these four occupations would you prefer

	Scored as interest in
Auto mechanic	Physical objects
Auto salesman	People
Efficiency engineer	Ideas
Calculating machine operator	Mathematics

2. A second interest test revealing strength of interest in the following vocational fields:
   a. Mechanical
   b. Computational
   c. Physical sciences
   d. Biological sciences
   e. Persuasion
   f. Art
   g. Literary
   h. Musical
   i. Social service
   j. Clerical

Typical question:

Rank from 1 (high) to 10 (low) your preference for each of the following courses of study:

	Scored as interest in
Slum Clearance	Social service
Office Practice	Clerical
Wood Working	Mechanical
Mathematics	Computational
Physics	Physical sciences
Zoology	Biological sciences
Salesmanship	Persuasion
Art Appreciation	Art
How to Write for Profit	Literary
Music Appreciation	Musical

3. An intelligence test which yields separate scores as to
   a. Memory
   b. Number facility
   c. Vocabulary
   d. Space perception (visualization)
   e. Reasoning

Typical questions:	In scoring, credited to
What city is the capital of Canada?	Memory
22 + 37 — 14 + 3 — 17 =	Number facility
Sapient means much the same as— WISE? OILY? SPLIT? FOOLISH?	Vocabulary
If you start from City A, drive 10 miles north, 5 miles east, then 10 miles south, how far from City A will you then be?	Space perception
If John is older than Bill, but younger than Henry, is Henry necessarily older than Bill?	Reasoning

These three tests required about two hours for completion. Tests were marked by a scoring team in a separate room, using scoring keys.

Using the intelligence test scores as a criterion, blanks were segregated into two piles:

1. Those grading 45 and over correct responses. These were tentatively considered as "qualified."
2. Those scoring under 45. These will usually be about two thirds of those volunteering in a search for talent.

The qualified blanks (representing employes with some gray matter) were further divided on the basis of interests into those who should be given—

a. A mechanical test (or tests)
b. A clerical test
c. Social development tests
d. Other tests, for artistic ability, social service, science information, etc.

Here are two sample questions from mechanical, clerical and social development tests:

Mechanical

Babbitt is—

A (A powder to fill cracks)
B (An anti-friction alloy)
C (A tongued joint)
D (A compound to make pipe joints watertight)

Mullions are most likely to be found in a—

A (Window)
B (Escutcheon)
C (Wainscot)
D (Balustrade)

Clerical

1850 firebricks @ $20.20 per thousand = $————

908523—980523 (are these numbers SAME or DIFFERENT?)

Social Development

I stammer when I'm flustered
I like to address groups

A profile or psychograph was drawn for each qualified employe. The man covered by Figure 1, for example, was a maintenance mechanic's helper recommended for training as an industrial engineer. Note that results of all tests are shown on a 1 to 10 (decile) scale to facilitate comparisons.

INTERVIEW. Based on the profiles and supporting test data, qualified employes were interviewed with their personnel records at hand. At this interview the significance of the test results was explained and suggestions offered as to personal development, courses of study or other ways to improve. Employes showed great appreciation for these interviews, discussed their ambitions and limitations quite freely. In quite a few cases the tests succeeded in clarifying a career choice which had been in doubt.

Some companies give this vocational counseling to all volunteers; others do it only with qualified volunteers but let it be known that any one may learn his test results if he will but inquire. Experience shows that rather few of the non-qualified do so; they seem to sense that they didn't do so well as those being interviewed upon management's initiative.

This company, selected as typical, revealed the following data:

450 employes
51 volunteered
34 failed to qualify
17 qualified as follows
11 for supervisory training
6 for mechanical work
2 for production control
4 for clerical

Six men qualified for two possibilities.

Thus it would seem that industry has in its own ranks a small but important supply of employes worthy of training as mechanics, supervisors, personnel workers, industrial engineers and scientific assistants.

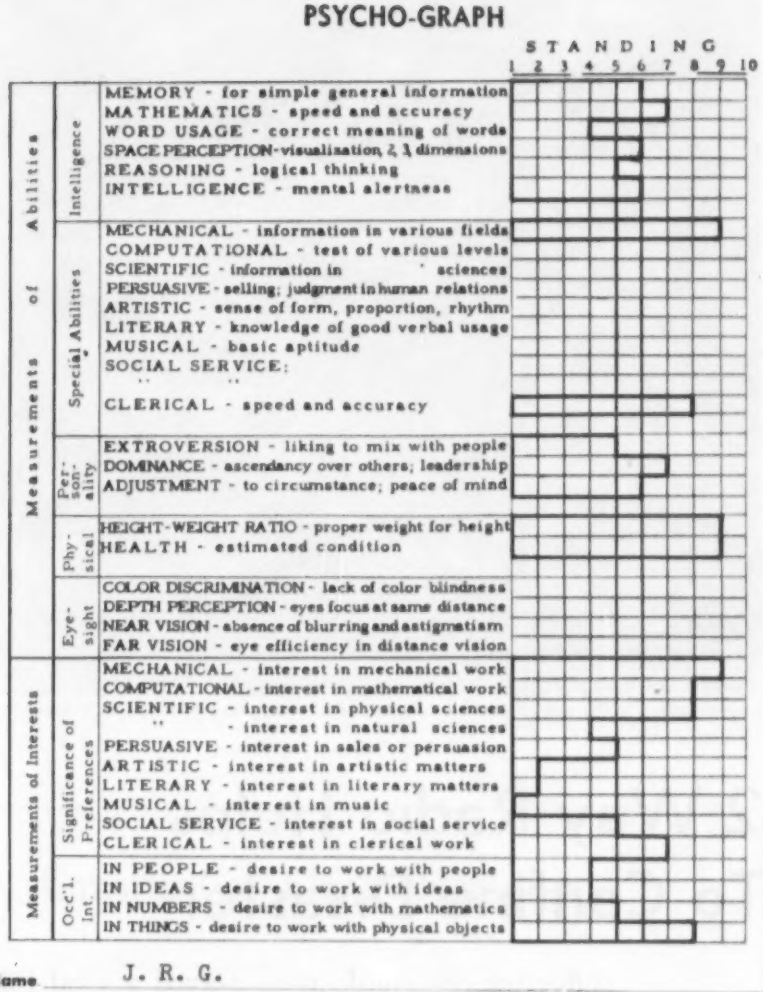
PSYCHO-GRAPH
STANDING
1 2 3 4 5 6 7 8 9 10
Measurements of Abilities
Intelligence
MEMORY - for simple general information
MATHEMATICS - speed and accuracy
WORD USAGE - correct meaning of words
SPACE PERCEPTION - visualization 2 & 3 dimensions
REASONING - logical thinking
INTELLIGENCE - mental alertness
Special Abilities
MECHANICAL - information in various fields
COMPUTATIONAL - test of various levels
SCIENTIFIC - information in sciences
PERSUASIVE - selling; judgment in human relations
ARTISTIC - sense of form, proportion, rhythm
LITERARY - knowledge of good verbal usage
MUSICAL - basic aptitude
SOCIAL SERVICE:
CLERICAL - speed and accuracy
Personality
EXTROVERSION - liking to mix with people
DOMINANCE - ascendancy over others; leadership
ADJUSTMENT - to circumstance; peace of mind
Physical
HEIGHT-WEIGHT RATIO - proper weight for height
HEALTH - estimated condition
Eyesight
COLOR DISCRIMINATION - lack of color blindness
DEPTH PERCEPTION - eyes focus at same distance
NEAR VISION - absence of blurring and astigmatism
FAR VISION - eye efficiency in distance vision
Measurements of Interests
Significance of Preferences
MECHANICAL - interest in mechanical work
COMPUTATIONAL - interest in mathematical work
SCIENTIFIC - interest in physical sciences
- interest in natural sciences
PERSUASIVE - interest in sales or persuasion
ARTISTIC - interest in artistic matters
LITERARY - interest in literary matters
MUSICAL - interest in music
SOCIAL SERVICE - interest in social service
CLERICAL - interest in clerical work
Occ'l. Int.
IN PEOPLE - desire to work with people
IN IDEAS - desire to work with ideas
IN NUMBERS - desire to work with mathematics
IN THINGS - desire to work with physical objects
Name J. R. G.
Age 27 Marital Status M Education 12 Years
Report: This man is worthy of training beyond his present level of maintenance mechanic's helper. His intelligence is above average, he is well informed in the mechanical field, possesses good speed and accuracy in clerical work.
Social development is average, or slightly better, especially as to his desire to dominate. Physically he seems to be in good shape.
His strong interests are in mechanical work, mathematics and physical sciences; he desires to work with physical objects.
With proper training this man should make good in industrial engineering, especially in studies of tools, equipment, jigs, fixtures, conveyorization and assembly line processes.

FIGURE 1

Every oil company has its quota of chronic grumblers. "No opportunity around this place," they say. But a company which has conducted a search for talent is in a strong position with any employe who complains that he has not been considered for advancement. "Enter your name for testing," he is told, "so that we will know in what direction your abilities lie." If he missed the first search, assure him that there will be others or that methods being set up will find out about his potentialities for higher tasks.

Management literature is currently replete with discussions of "non-financial incentives." It is difficult to conceive of any more galvanizing, loyalty-producing motivation than sure knowledge on the part of employes that there is in effect a carefully conceived program of internal promotion, one designed to utilize talents for the right types of job. # #

FIGURE 1—His battery of telephones dead, trucking office dispatcher (inset) handles emergency communications traffic over 25-watt base station. Aerial photo shows Whiting fire 30 hours after the blast.

2-Way Radio Helps To Confine Disaster

Effective communications played a vital role in curbing Standard's Whiting fire.

WHEN DISASTER STRIKES, a reliable two-way communications system can mean the difference between total destruction and comparatively small damage.

The disaster and fire at the Whiting refinery of Standard Oil Company (Indiana) last August made this point unmistakably clear. Because the refinery had its two-way radio—and a workable disaster plan—ready well in advance, total devastation was confined to a relatively small area of 10 acres.

The first blast occured at 6:10 on Saturday morning at the 26-story fluid hydroformer, the first of its kind in the world. The new reforming unit was being returned to operation after a shutdown for examination.

Nearby storage tanks, which had been punctured by flying fragments, were soon ignited, the first of a series of about 70 tanks which ultimately were damaged or destroyed. Flaming oil began to flood the area.

The blast was followed immediately by the sounding of the refinery disaster siren which summoned refinery employes and fire-fighting units to the scene. The immediate objective was to confine the blaze to the smallest possible area.

Foam was applied to burning tanks and the spreading oil pools, and hundreds of water hoses played on adjacent tanks which were nearing the bursting point because of the intense heat.

Within three hours a successful fire-fighting pattern had been established. Scores of truck-loads of sand were rolling toward Whiting and into the refinery for construction of emergency dikes.

At this point the fire ate into the main telephone terminal block, throwing the entire plant telephone system out of commission. This had no effect on the efficient dispatching of sand trucks to one critical zone after another as the fire progressed. They were directed to their destinations by Standard mobile units stationed at strategic points along plant boundary roads, at plant gates and close to the disaster scene itself. Every key traffic area and critical zone had a mobile unit, with runners, which relayed orders from the fire marshal's office.

Until the telephone failure, all sand truck dispatching instructions and orders to the positioned mobile units had gone out over the 250-watt base station on top of the company's Administration and Engineering building. When the telephone block burned out, the signal and control lines to the transmitter were destroyed. But the dispatching was quickly restored by moving a mobile radio truck beside the fire marshal's office where temporary headquarters were established.

A second dispatching point had to be re-established at the refinery trucking office, the focal point and maintenance station for all its rolling stock. This office, which also had been using the 250-watt base station through remote control facilities, likewise pressed into service a mobile radio truck stationed just outside the dispatcher's window. Another unit was converted into a dispatching point at the main plant protection office. Although the mobiles radiated only 10 watts of power their signals blanketed the area clear and strong.

With 3 of the 5 dispatching points back in operation, additional manpower was called in. Three AC-operated auxiliary base stations were added to the revamped communications system. These units were delivered and put into operation at the refinery within a few hours, greatly improving dispatching facilities and relieving the three mobile units for duty at the disaster scene.

Before the explosion, the refinery's Special Industrial radio system consisted of 36 mobile units in various plant vehicles, two portable sets and the 250-watt base station controlled from any one of five remote control dispatching points.

After the emergency was over the

system had grown to include 3 separate 25-watt base stations plus 20 portable pack sets and 5 portable sets, for a total of 63 mobile and portable units and 4 base station units.

Perhaps the one occasion when two-way radio demonstrated most dramatically its inestimable value in an emergency was late Saturday afternoon when a flareup occurred at a naphtha storage tank, sending orange flame hundreds of feet into the air. The intense heat touched off a blaze in the vent of the nearest tank in the Indiana tank field.

The field, separated from the main processing section of the refinery by the highway, is a long, narrow peninsula containing more than 30 storage tanks. It is near a residential area of Whiting which had been evacuated.

A driver in the nearest Standard mobile truck, seeing the fire break out in the tank, interrupted the dispatching traffic with a high priority request for all available fire equipment to be rushed to the scene. The fire was extinguished within a few minutes.

By Monday evening the blaze was under control and was burning itself out. Wind conditions were favorable, allowing the heat to rise straight from the tanks. Though tired, emergency workers were still standing by as the last fire was being brought under control.

Then word was received that the weather bureau had posted warnings of a possible tornado in northern Indiana, although not as far north as the refinery. Twenty additional pack sets and 5 portable sets were ordered for delivery as soon as crystals for the Standard Oil frequency of 153.23mc could be ground and installed at the factory. Delivery was expected Monday evening, and the possibility of high winds that might have spread the fire underscored the importance of getting this additional communications equipment.

Fortunately, the portable equipment was not vitally needed, except as an additional precautionary measure. A short time later the wind shifted and it started to rain.

Although the weather and power failure posed constant problems, the disaster plan was executed masterfully—even heroically—by the company fire-fighting corps whose equipment and every move were directed by the two-way radio communications system. ##

FIGURE 2—One of Standard's mobile trucks which dispatched fire fighting equipment and relayed emergency orders to firemen.

Construction plans revamped

The Whiting fire resulted in a complete revamping of Indiana Standard's plans for immediate and long range construction, including:

- Standard will begin construction of its new 14,000 bpd Ultraformer immediately instead of in 1957, as had been previously planned. It will duplicate a unit being built at Standard's Sugar Creek, Mo., refinery.
- Repairing and rebuilding of pump houses and equipment in the fire-damaged area is well under way. Some of the equipment already has been returned to service.
- Building new tanks, including a new field of 20 on vacant property, to replace in part the 70 burned out tanks. The new tank field is now being prepared.
- Rearranging the use of undamaged, where practical, to let essential operations continue while the new tanks are being built. This program is well along. It has permitted crude running operations to be resumed at a rate of about 100,000 barrels a day and will be increased as soon as possible. Throughput is expected to reach 150,000 bpd very shortly.
- Rebuilding or replacing the damaged fluid hydroformer. This is contemplated later in the over-all program, after engineers have thoroughly inspected remaining usable parts and carefully evaluated alternate possibilities.

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at highest working pressures

At pressures up to 2000 psi, this Meriam Manometer provides critically accurate flow or differential pressure measurement. Constructed of solid bar stock steel, all parts are precision fitted, hand lapped. Each unit is cold hydraulic tested to 5000 psi.

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Write for Bulletin C-12.

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FIGURE 1—Cleaning these hands with a strong petroleum solvent instead of a good industrial cleanser resulted in this dermatitis.

Skin Disease: Hazard to Refinery Workers

SKIN DISEASES are a principal source of lost man-hours among refinery workers, a recent survey shows. Out of 14,000 refinery people, 473 or 3.3 percent were found to have dermatosis (see Table 1).

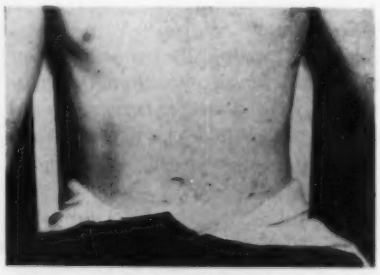
"Diseases of the skin are taking a far larger toll of the nation's industrial output, in terms of lost productive time and compensation payments, than all other occupational diseases combined. The cost to industry of the average industrial worker hit with a skin disease is: 10 weeks off the job; $100 in compensation payments; and $90 for medical care; totalling far more than $100 million annually."

These statements were made by Dr. Louis Schwartz, widely known industrial dermatologist, in his recently published booklet, *The Prevention of Occupational Skin Diseases.*

Recent statistics compiled from a pilot survey of 11 states by the Division of Occupational Health of the Public Health Service reveal that industrial skin diseases annually account for 75.3 percent of all occupational diseases. In the 11-state area alone, 6817 cases of skin disorders were reported, as against 2241 cases of all other occupational diseases.

"The menace of occupational skin diseases to the health and life of America's 60 million or more workers can be radically reduced by the inauguration of adequate plant cleanliness programs and most skin diseases can be entirely avoided by proper washing procedures, showering and wearing of clean and suitable clothing," Dr. Schwartz explained.

Dr. Schwartz also indicates the major causes of occupational dermatitis. Highest on the list are cases reported due to petroleum products and greases—18.8 percent—while the few-



This worker has chloracne, caused by clothing soaked in cutting oils. It could be prevented by after-work showers and a daily change of work clothes.

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Engineer at work!

If you were to walk into the Engineering Department of our Philadelphia headquarters, chances are you'd see a vacant desk or two like this. And for good reason!

The engineer who occupies this desk might be in Maine, California, Texas . . . anywhere in the country providing supplemental assistance on water problems . . . helping your *personal* representative, the Betz District Engineer and *you* to do a better job in your plant.

He's one of a group of over 20 Betz specialists that make up our fully-staffed Engineering Department . . . providing *additional* headquarters engineering support as well as in-the-field engineering as required.

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NEW HI-THRUPUT HERRINGBONED MIST ELIMINATOR

Check these important points:

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2. Safe operating limits – 10% to 12% higher velocity.
3. Entrainment removal practically 100% over wider operating range.
4. Three to four times longer on-stream life under coking conditions or where solids are present.
5. Lower cost – wires repositioned by Herringbone Fold*.

*U.S. Patent No. 2,565,846, Aug. 28, 1951

These photos show the difference. Full explanation given in our Booklet ME-5.

Send for Revealing Booklet ME-5. Learn how repositioning wires by patented Herringbone process and change in size and contour of mesh openings make this new Mist Eliminator more effective and economical.

METAL TEXTILE CORPORATION

Roselle, New Jersey

Metal Textile Corporation of Canada, Ltd., Hamilton, Ont.

As Management Sees It . . .

TABLE 1—Yearly Prevalence of Occupational Dermatoses by Industries

INDUSTRY	Number of Workers	Dermatoses	Percent
Synthetic resin manufacture	700	53	7.5
Chemicals and dye manufacture	2,500	176	7.0
Tanning	565	20	3.5
Oil refining	14,000	473	3.3
Candy manufacture	1,236	36	3.0
Fabric dyeing	3,800	76	2.0
Rayon manufacture	4,000	80	2.0
Steel manufacture	3,500	52	1.5
Fur dyeing	1,600	17	1.0
Rubber manufacture	8,000	84	1.0
Glass manufacture	5,700	54	1.0
Automobile manufacture	72,000	281	0.4
Total	117,601	1,402	1.2

TABLE 2—Causes of Occupational Dermatitis

Material Exposure	Number	Percent
Petroleum products and greases	7,805	18.8
Alkalis (and cement)	4,881	11.7
Solvents	3,265	7.8
Plants and woods	2,719	6.5
Metals and metal plating	2,482	6.0
Rubber and its compounds	1,314	3.2
Burns, physical and mechanical agents	1,313	3.2
Chemicals, unspecified	1,253	3.0
Paints, enamels, and varnishes	1,132	2.7
Acids and acid fumes	978	2.4
Dyes and dye intermediates	974	2.3
Chromates and chromic acid	727	1.7
Biologic agents	520	1.3
Coal tar products	462	1.1
Furs and fur dyes, and hides	425	1.0
Synthetic resins	390	0.9
Non-metallic elements	185	0.4
Oils, vegetable (oils, fats, and waxes)	92	0.2
All other known exposures	8,064	19.4
Unknown exposures	2,647	6.4
Total	41,628	100.0

est number of cases—0.2 percent—result from vegetable oils, fats and waxes (see Table 2).

Following are the five major causes of skin diseases:

- Mechanical (friction, pressure, injury)
- Physical (heat, cold, radiation)
- Plant poisons (several hundred woods and plants)
- Biological (bacteria, fungi, mites, etc.)
- Chemical agents—"primary irritants," such as strong acids or other corrosives; and "sensitizers" like TNT or resins that do not cause dermatitis at once but pave the way on further contact.

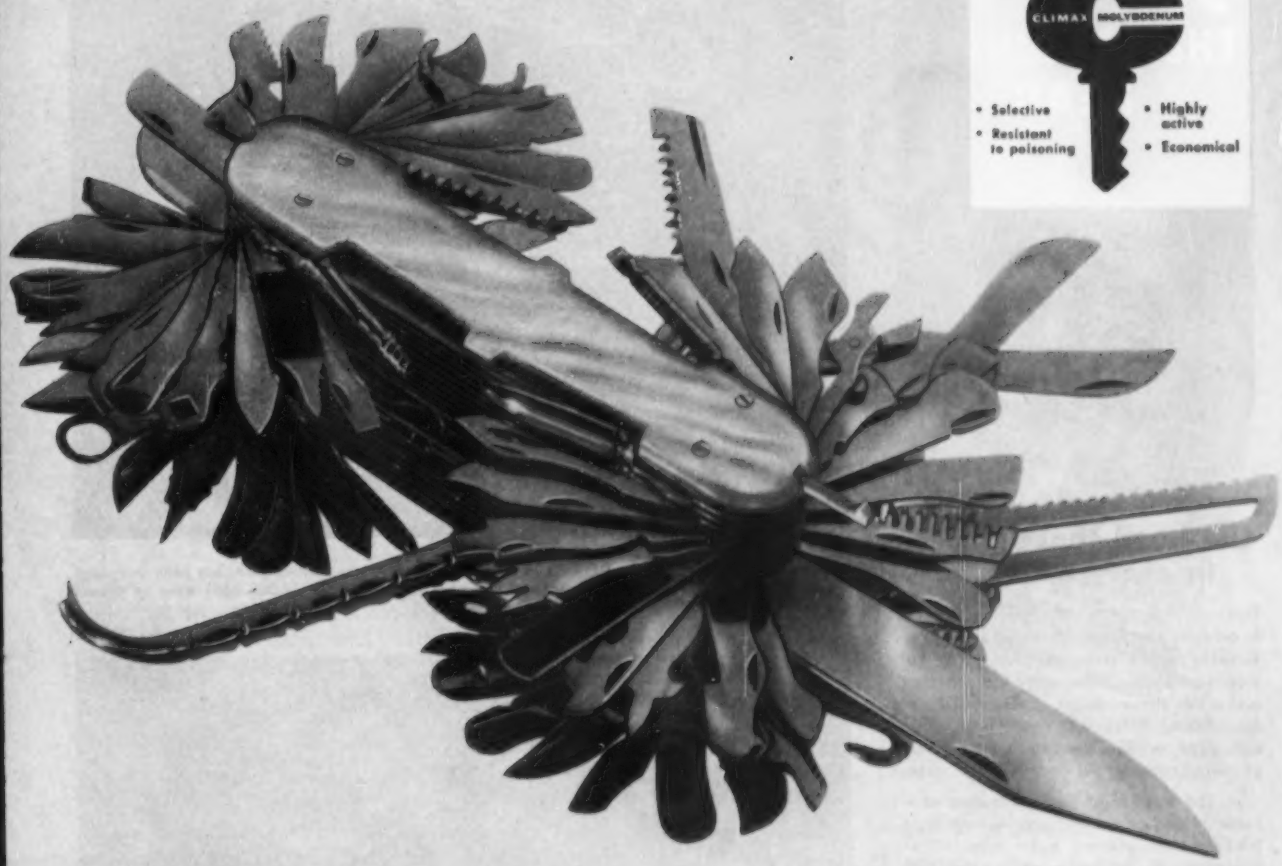
The synthetic resin, chemical, petroleum and automobile industries rank high on the list of occupations most subject to dermatosis. Other industries include food canning, rayon, rubber and glass manufacture.

The most effective measures for preventing dermatosis on the job are relatively simple. Establish a program of personal hygiene that will:

1. Provide running hot and cold water, a proper industrial cleanser and towels no further than 100 feet from the place of work; and enough showers so no worker need wait more than a few minutes.
2. Educate workers thoroughly in the importance of personal cleanliness, through posters, safety meetings and campaigns.
3. Allow for inspection of workers' skin at periodic intervals.
4. Provide the skin cleaner best fitted to combat the irritants involved in a particular type of industry.

Beyond personal cleanliness, environmental cleanliness—often called "good housekeeping"—is essential in any industrial plant. Good industrial housekeeping reaches into many corners, and includes proper plant ventilation and design in order to reduce initial contact with irritants to a minimum, and the provision of protective clothing where warranted. Of considerable help, too, are vanishing, water-repellent or solvent-repellent ointments and creams, and special lotions to prevent excessive drying and chapping of the skin.

Difficult to detect and diagnose, often resistant to treatment, most industrial skin diseases have proved to be test cases of the old adage, "an ounce of prevention is worth a pound of cure." ##



Moly catalysts are versatile

Because of its versatility, molybdenum is one of the most widely used catalytic elements. As a transition element, it has the incomplete inner shell of electrons needed for catalytic activity. Ease of transition from one to another of its six valence states allows it to function readily as an electron acceptor or donor. It forms a variety of compounds in all valence states, most of them resistant to common catalytic poisons. Commercially, molybdenum catalysts are used in seven types of reactions: oxidation, hydrogenation, dehydrogenation, isomerization, cyclization, chlorination and condensation. Promising results have been obtained in dehydration, polymerization and alkylation. For complete data write Department 25, Climax Molybdenum Company, 500 Fifth Ave., New York 36, N. Y. for our bulletin, "Molybdenum Catalysts for Industrial Applications."

CLIMAX MOLYBDENUM

Courtesy of Hoffritz for Cutlery, 331 Madison Avenue, New York

"SERV-RITE"
THERMOCOUPLE
HEAD

the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

Write for complete details

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As Management Sees It . . .

Since World War II the capacity of Texaco's Los Angeles Works, Wilmington, has been increased from 40,000 to 60,000 barrels daily. A new catalytic reforming unit (10,000 bpd) went on stream in June, 1955.

Texaco's second largest refinery, Lockport, Ill., has a crude capacity of 65,000 barrels daily. The latest catalytic reforming unit (11,000 bpd) was added since the above photo was made. Water transportation to the Great Lakes and Mississippi River points is had by means of the canal at left.

Texaco Growth

Continued from Page 139

finery is scheduled for completion early next year.

The company's largest refinery is at Port Arthur, Texas, where daily capacity of 135,000 barrels in 1945 has been increased to 210,000 barrels. This refinery today has fluid catalytic cracking units with a daily capacity of 60,000 barrels, and catalytic reforming units with a capacity of 40,000 barrels. Additional modern facili-

ties for manufacturing lubricating oil were added in 1948, increasing lubricating-oil capacity by 50 percent. The Port Arthur works also has one of the world's largest grease plants.

Texaco's second largest refinery, at Lockport, Ill., has a charge capacity of 65,000 barrels of crude oil a day. The Los Angeles Works and Eagle Point Works rank next, each having a rated capacity of 60,000 barrels.

A substantial amount of petrochemicals manufacturing activity is carried on by the Refining department. In this field, in addition to the manufacture of a petroleum-derived additive used in Texaco's premium gasoline, lubricating and grease additives, P-T anti-freeze and other petrochemicals are produced. To take further advantage of the availability within the company of raw materials for petrochemicals manufacture and of the developments of its chemicals research activities, Texaco is making plans for further expansion in the petrochemical field.

Two of its largest petrochemical ventures have been undertaken jointly with other companies. With American Cyanamid Company, Texaco jointly owns the Jefferson Chemical Company, which began operations in 1948. Jefferson's plant at Port Neches, Texas, uses refinery gases supplied by Texaco's Port Arthur Works.

Texaco and United States Rubber Company jointly own Texas-U.S. Chemical Company, which was organized to make synthetic rubber from petroleum derivatives. This affiliate has acquired the government synthetic-rubber plant at Port Neches, Texas, and a one-half undivided interest in the butadiene plant there. Raw products for butadiene are supplied by the Port Arthur refinery.

Texaco's Research and Technical division was a part of the Refining Department until 1954, when it was set up as a separate department.

John S. Worden, vice president in charge of all domestic refining operations of The Texas Company, has pointed out that Texaco's record investment for refineries was more than $70 million in 1954. Expenditures for refineries in 1955 will be less, but according to Worden capital outlays will continue in amounts sufficient to "provide for efficient manufacture of gasolines of top quality." ##

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Grating for Every Need
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STEEL
for the 1001 applications where safety and strength come first. Kerrigan Steel Grating is BONDERIZED for corrosion resistance and extra years of life.

STAINLESS and MONEL
non-magnetic steel for the chemical, oil and packing industries . . . for ANY installation where high resistance to heat, acids, chemicals, and corrosion is needed.

TRULY . . .
In both size and type, there is a Kerrigan Weldforged grating for every need. Let our new catalogs prove it to you. Send for the one you think best answers your need (or ask for ALL FOUR if you wish). We will also be glad to send you a desk-size grating sample. Write Kerrigan Iron Works, Inc., General Sales Office, 274 Madison Ave., New York City.

RIVETED STEEL
where it is desired to match existing grating.

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spark-proof for those whose need is strength AND lightness. Extra safe and strong. Allowable fiber stress 15,000 psi. Modulus of elasticity 10,000,000 psi.

KERRIGAN GRATING
CUSTOM-MADE FOR YOUR JOB AND SAFE—IT'S Weldforged

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . in the Industry

Refinery Profits Up For First Half of 1955

Petroleum refinery sales for the first half of 1955 ran more than $11 million, or 6 percent higher than for the same period a year ago. These figures are based on a report by the Securities Exchange Commission. Profits after taxes were up 7 percent, comparing with the national industry average of 10 percent increase in sales and 31 percent increase in profits for that period.

Petroleum refinery sales for the first half of 1955 were $11,035,000,000, as compared to $10,417,000,000 for the first six months of 1954. Refinery profits after taxes left refinery profits at $1,141,000,000 for the first half of 1955, as against $1,063,000,000 for that period a year earlier.

API to Hear Top Speakers At San Francisco Sessions

Heading a list of speakers to appear before the American Petroleum Institute at its 35th annual meeting are California Governor Goodwin J. Knight, Washington's Governor Arthur B. Langlie, and Treasury Secretary George M. Humphrey. The meeting will be held in San Francisco November 14-17.

Governor Knight will address a general session Wednesday, November 16, and secretary Humphrey will speak at the final general session Thursday morning. Both sessions will be held in Curran Theater.

Governor Langlie will be principal speaker at the public relations session on the opening day of the meeting. Appearing on the same program will be W. R. Huber, public relations director for Gulf Oil Corporation and chairman of the Oil Industry Information Committee.

Scheduled to appear with Governor Knight at the Wednesday program is Walter S. Hallanan, president of Plymouth Oil Company, Pittsburgh. The assembly also will hear remarks by API President Frank M. Porter.

At the Thursday session, speakers beside Secretary Humphrey will be H. S. M. Burns, president of Shell Oil Company, New York, and S. Clark Beise, president of San Francisco's Bank of America.

Other prominent figures to address various sessions of the four-day meeting are Lieutenant General James H. Doolittle, vice president of Shell Oil Company, and T. S. Petersen, president of Standard Oil Company of California.

Recognition—A number of men prominent in petroleum refining and related fields will be cited for service to the industry. Those to be awarded the API "Certificate of Appreciation" at various group and committee sessions are as follows:

Oil Industry Information Committee—L. R. Kamperman, Leonard Refineries, Inc.; Roy M. Stephens, Humble Oil & Refining Company; H. E. Brandli, Cities Service Oil Company; Willard Burnap, Western Oil & Fuel Company; Robert A. Douglass, Ethyl Corporation; Calvin Houghland, Direct Oil Company; J. S. Morrison, American Oil Company, and T. F. McGarey, Cities Service Oil Company.

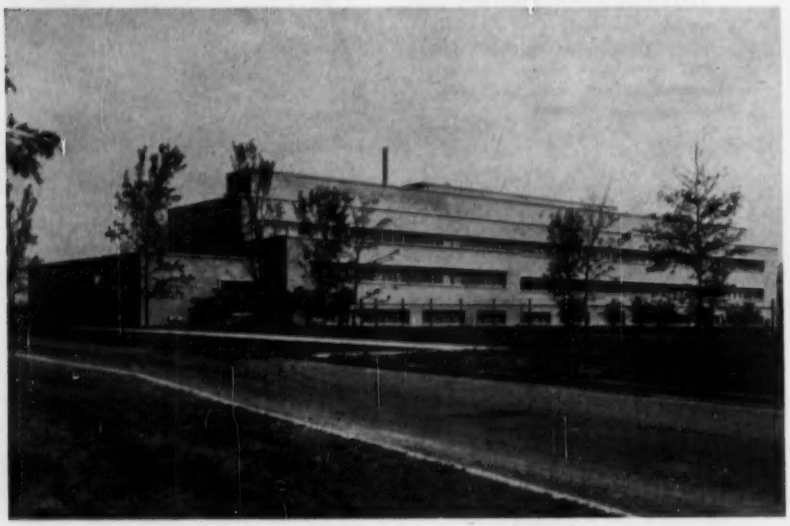
Safety—R. W. Black (deceased), formerly with Esso Standard Oil Company; R. E. Donovan (deceased), formerly with Standard Oil Company of California; C. L. Hightower (deceased), formerly with United Gas Pipe Line Company; J. L. Risinger, Socony Mobil Oil Company, Inc.; R. B. Roaper, Humble Oil & Refining Company, and W. N. Young, Shell Oil Company.

Research—Howard G. Vesper, Standard Oil Company of California, and Frederick H. Lahee, Sun Oil Company.

Finance and Accounting—E. Chester Peet, Royal Dutch Shell.

Highlights—A new feature of this year's meeting will be a medical and health session. This will be held on the opening day, under the sponsorship of the institute's Medical Advisory committee. Topics to be discussed include industrial hygiene in the petroleum industry, the noise problem and "the aging, ailing truck driver."

Other sessions of special interest to the refining industry will cover a report from the OIIC, the election of a new General Committee for the Division of Refining, a report of the Board of Councillors and the



UOP Opens New Laboratory—

Three-stories-high and 312-feet-long, Universal Oil Products Company's new buff-brick research laboratory building provides more than 60,000 square feet of office and laboratory area. The new building is of concrete beam and slab construction, with slate panels between aluminum window frames. Windows are one-inch-thick thermopane glass.

UNIVERSAL Oil Products Company has stressed space utilization and convenience in the design of its recently-completed research laboratory at Des Plaines, Ill. The building was started in April, 1954, after company officers and research men had visited research facilities for more than five years to evaluate the best in design ideas.

A few of these features were placing all laboratories on the north side of the building to insure the best possible light; locating offices directly across the hall from the laboratories; housing utility lines in shafts accessible from halls, with shut-off valves controlling flow to each laboratory room; air conditioning for temperature and humidity control, and segregation in a separate wing of all laboratory functions that operate on a continuous basis.

There are 31 separate laboratory units along the north side, with the south side divided into 39 offices and conference rooms, balance, instrument and computing rooms. There is a large photo laboratory, a glass-blowing shop, mechanical equipment room and a technical library with stack space for more than 10,000 volumes.

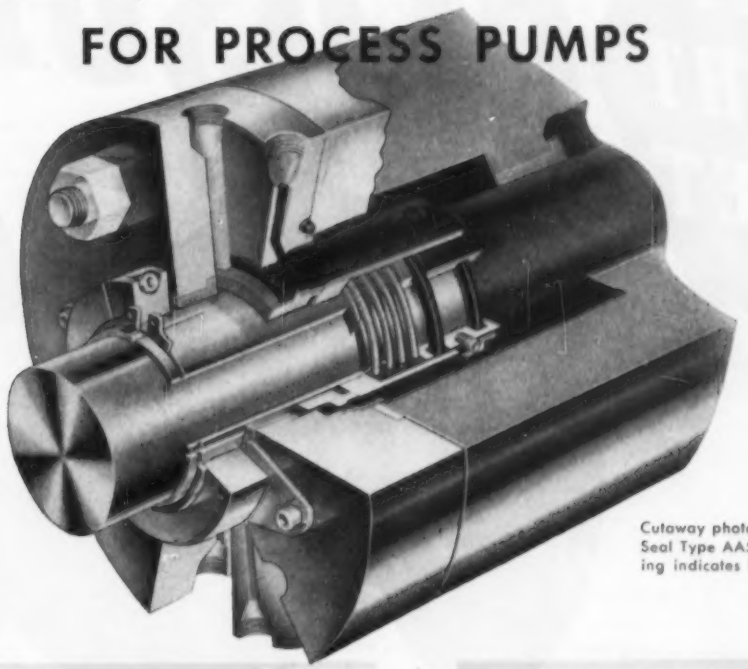
Below the ground level is a bomb shelter that normally will function as an auditorium for up to 225 persons but can, through the use of folding panels, be divided into a series of conference rooms. The space, covered by reinforced concrete, has independent ventilation and power generating units, a first-aid room and storage for emergency food rations.

A semi-works wing houses laboratory activities operating on a 24-hour basis. Included are two sample rooms, one constantly maintained at 35 F. and the other at 100 F.

NEW from GARLOCK...

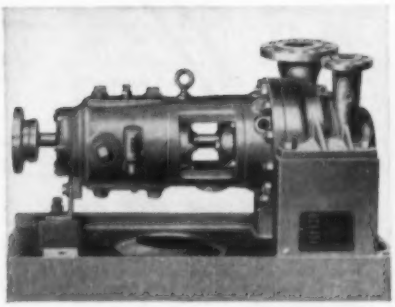
MECHANIPAK* SEALS

FOR PROCESS PUMPS



Cutaway photo of Garlock Unitary Seal Type AA51B-23. Yellow shading indicates liquid being sealed.

- **One Piece Assembly**
- **Quick, easy installation**
- **Pre-set at factory**
- **Maintenance-free life**



Typical refinery process pump for which Garlock Unitary Seals are designed.

SAVE installation time, eliminate maintenance costs with Garlock's new Unitary Mechanipak Seals for process pumps!

The entire unit, including sleeve and gland, is furnished completely assembled. The seal is pre-set at the factory—no on-the-job adjustments are needed. The *external* lock and drive is readily accessible—eliminates set-screw drive.

Get all the facts today! Phone your Garlock representative or write for new Folder AD-151.

The Garlock Packing Company, Palmyra, New York

Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N. Y.), Philadelphia, Pittsburgh, Portland (Oregon), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK

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For more data on advertised products, use Readers' Service Cards, last page.

Only Chapman Tilting Disc Check Valves give you

FAST TIGHT QUIET CLOSURE

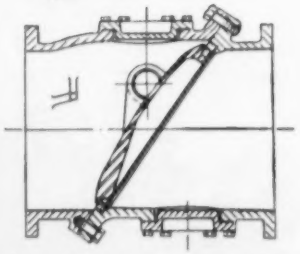
Fast, quiet operation means low cost operation for check valves. That's exactly what the Chapman Tilting Disc Check Valve is designed to do. It won't flutter or slam and damage the piping joints or the valve itself. The unique drop-tight closure action eliminates scraping and wear of the disc and seat.

Rugged construction and low wear of the Chapman Tilting Disc Check Valves mean long life under severe operating conditions. Absence of vibration plus low head loss keep maintenance of the entire piping system at a minimum.

Whether for replacement or for new piping systems, be sure to specify Chapman Tilting Disc Check Valves. They're available in iron and steel for handling fluids or gases under a wide range of pressures. For full data on the complete line, write today. Ask for Catalog 30-A.

The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS

Here's why Chapman's Tilting Disc Check Valves Keep Quiet All of Their Lives



This specially designed "airfoil" disc balances perfectly in open position. The fluid holds the disc tightly against its stops without flutter. The body of the valve is larger around the disc, so the net valve area is at least as much as the pipe area to assure low flow resistance.

When the flow is reversed, pressure against the upper part of the disc cushions it as it closes. Then the disc drops easily and tightly to its beveled seat after the valve has swung closed. Seating is fast and quiet with minimum head loss in all but unusual piping arrangements.

What's Happening. . .

election of API directors.

A group session on petroleum statistics will have financial implications, with three speakers giving commentaries and forecasts on economic problems. They are Walter E. Hoadley, Jr., treasurer and economist for Armstrong Cork Company, Lancaster, Pa.; John G. Winger, petroleum economist with The Chase National Bank, and N. B. Guyol, United Nations staff statistician.

Sessions—All sessions important to the refining industry will be held at the St. Francis Hotel, except the general sessions at Curran Theater and the public-relations and medical and health sessions, which are set for the Hotel Fairmont. The program includes:

Monday, November 14

Medical and Health Session—Sponsored by the Medical Advisory Committee. Presiding: M. J. Rathbone, Chairman, API Medical and Health Committee; Standard Oil Company (New Jersey). "API Medical Activities," George M. Saunders, M.D., Chairman, API Medical Advisory Committee; Socony Mobil Oil Company. "The Aging, Ailing Truck Driver," M. N. Newquist, M.D., The Texas Company. "Industrial Hygiene in the Petroleum Industry," J. W. Hammond, Humble Oil and Refining Company. "Some Practical Aspects of the Noise Problem," Howard P. House, M.D., and Aram Glorig, M.D., University of Southern California.

Public-Relations Sessions—Presiding: H. S. M. Burns, Chairman, Public-Relations Committee, API Board of Directors; President, Shell Oil Company. "Oil Industry Information Committee Report," W. R. Huber, Chairman, Oil Industry Information Committee; Gulf Oil Corporation. Address: Arthur B. Langlie, Governor of Washington.

Refining Session—Presiding: E. B. McConnell, Vice President for Refining, American Petroleum Institute; Vice President, The Standard Oil Company (Ohio). "Report of Division's Nominating Committee," F. L. Craise, Standard Oil Company of California. Election of Members of the General Committee of the Division of Refining. Address: Dr. J. E. Wallace Sterling, President, Stanford University. Address: Lieutenant General James H. Doolittle, Vice President, Shell Oil Company.

Tuesday, November 15

American Petroleum Industries Committee Open Meeting—Presiding: Robert H. Scholl, Chairman, American Petroleum Industries Committee; Esso Standard Oil Company. Address: John M. Peirce, Director of Finance, State of California. Address: T. S. Petersen, President, Standard Oil Company of California.

Wednesday, November 16

General Session—Presiding: P. C. Spencer, Chairman, API Board of Directors; President, Sinclair Oil Corporation. Report of Board of Councillors and Election of Directors. Remarks: Frank M. Porter, President, American Petroleum Institute. Address: Goodwin J. Knight, Governor of California. Address: Walter S. Hallanan, President, Plymouth Oil Company.

Committee on Petroleum Statistics Open Session—Presiding: Henry N. F. Schwall, Chairman, API Committee on Petroleum Statistics; Shell Oil Company. "The General Economic Outlook for 1956," Walter E. Hoadley, Jr., Treasurer and Economist, Armstrong Cork Company. "Probabilities of Petroleum Demand," John G. Winger, Petroleum Economist, The Chase Manhattan Bank. "Oil in the Total Energy Market," N. B. Guyol, Staff Statistician, United Nations.

Thursday, November 17

General Session—Presiding: P. C. Spencer, Chairman, API Board of Directors; President, Sinclair Oil Corporation. Address: H. S. M. Burns, President, Shell Oil Company. Address: S. Clark Beise, President, Bank of America. Address: George M. Humphrey, Secretary of the Treasury.

To Take Up Refining El Paso Natural Gas

El Paso Natural Gas Company is in the process of acquiring McNutt Oil & Refining Company, operator of a 3200-barrel-a-day refinery at Brickland, N. M. The acquisition would mark El Paso's first venture into petroleum refining.

The refinery is equipped with a 1200-barrel-a-day thermal cracker, a 600-barrel-

More than a mere pipe fitting!
catawissa
PERFECT SEAL
unions
give a 3 to 1
safety factor
PLUS
A PERFECT SEAL!
THERE'S A CATAWISSA PERFECT SEAL UNION FOR EVERY USE . . . ALL TEMPERATURES, ALL PRESSURES!
The full dependability of HOT FORGED STEEL is yours in a Catawissa Union (hot forged from solid steel bars) with several extra value features that are exclusive here at the UNION SPECIALISTS!
All Catawissa Unions are designed to give a 3-to-1 SAFETY FACTOR . . . 3,000-lb. service unions are tested to 9,000-lbs., 6,000-lb. service unions tested to 18,000-lbs., etc.
Exclusive Ball-to-Angle seat design assures a PERFECT SEAL even when the pipe is not in alignment!
Machining operations assure a UNIFORMITY AND ACCURACY heretofore found only in special fittings and, with rigid inspection both during and after machining, guarantees LEAKPROOF CONSTRUCTION!
Satisfaction is guaranteed in any application—whether it be general low pressure service or extremely high pressures and temperatures (for air, oil, gas, chemicals, hot oils, gases or steam).
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AVAILABLE FROM LEADING INDUSTRIAL SUPPLY FIRMS
CATAWISSA VALVE & FITTINGS COMPANY
25 MILL ST. ★ CATAWISSA, PENNA.

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REDUCE THE CHANCE OF USING THE WRONG VALVE LUBRICANT

ELIMINATE LARGE WAREHOUSE STOCKS

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DESCO
PLUG VALVE
LUBRICANTS
ARE ALL YOU NEED
no matter what passes thru your valves!

No matter what the fluid or its temperature, Desco Lubricants are guaranteed to STAY in your valves . . . and 4 types are all you need.

Desco Lubricants will not harden or coke-up because they are ALL lubricant and contain no inert material.

CONVENIENT STICKS OR BULK
Packed in clean, convenient sticks in 5 sizes for gun or jack screw. Also in 5-quart, 5-gallon, and 100 lb. bulk containers.

The Only Complete Plug Valve Lubrication Company

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PLUG VALVE
LUBRICANTS
AND EQUIPMENT

LUBRICANTS FITTINGS GUNS LUBRICATORS

What's Happening. . .

a-day Platformer and a catalytic-polymerization unit with a daily capacity of 40 barrels. El Paso is expected to install additional facilities to permit blending and direct processing of gas liquids.

The company, a producing and pipelining concern, already turns out some 25,000 barrels a day of natural gasoline and LPG products. The output comes from its natural-gasoline plants in West Texas and New Mexico.

Plans for the purchase call for the exchange of 49,450 shares of El Paso common stock for the entire 150,000 shares of McNutt common. A listing of the stocks will be submitted to the New York Stock Exchange.

Gulf Publishing Expands REFINER Advertising Staff

Gulf Publishing Company has opened a North Texas district office, and named Ed Thompson to manage the new territory. He will headquarter at the Santa Fe Building, Second Unit, in Dallas.

Dunn

Assigned to the company's Cleveland office is Harvey W. Dunn as representative for PETROLEUM REFINER and *The Refinery Catalog*. In the newly-enlarged Cleveland territory, Dunn will be associated with Bill Westfall, district manager for Gulf Publishing Company at Cleveland since 1948.

Dunn comes to the REFINER from Chicago, where he was a member of the *Chicago American* advertising staff. In advertising work since 1948, he also has served the *Tulsa World*. In addition to a degree in journalism from the University of Missouri, he has completed graduate courses in advertising design, layout and typography.

Thompson, who also has had extensive advertising experience, will concentrate most of his efforts on the REFINER's sister publications, *World Oil*, *Pipe Line Industry* and *The Composite Catalog*, but he will be available for consultation on problems concerning refining-industry advertising and cataloging.

ODM Sets New Goal For Synthetic Glycerine

A program to expand the petroleum-derived glycerine capacity by 70 million pounds a year by June 30, 1957, has been approved by the Office of Defense Mobilization. Existing facilities include capacities for 140 million pounds a year of natural and 115 million pounds of synthetic glycerine.

The new increase will bring total capacity to 325 million pounds a year. Applications for fast write-off certificates under the expansion program must be submitted by June 30, 1956.

Receive AEC Permits

Three more petroleum concerns have been given access permits by the Atomic Energy Commission. They are Magnolia Petroleum Company, Socony Mobil Oil Company, Inc., and The Texas Company.

Government Receives Bids To Buy Institute Plant

Rubber Producing Facilities Disposal Commission has received five proposals to buy the government-owned copolymer plant at Institute, Va. Bids came from Goodrich-Gulf Chemicals, Inc., Goodyear Synthetic Rubber Corporation, Imperial Commodities Corporation, Edwin W. Pauley, Union Carbide and Carbon Corporation Company, and United Rubber and Chemical Company.

Negotiations with the bidders started immediately and will be completed by the year's end, with approval of the Attorney General required for any proposed sale. A report will be filed with Congress within ten days after it convenes in January, for Congress to take up the commission's recommendations within the following 30 days.

Goodyear Synthetic Rubber Corporation purchased the government's 15,200-ton Akron, Ohio, plant and its 99,600-ton plant at Houston. Goodrich-Gulf Chemicals, Inc., bought the 88,000-ton synthetic rubber and the 190,000-ton butadiene plant at Port Neches, Texas.

Petroleum Products Up From Output Last Year

The output of crude products from petroleum and natural gas amounted to 13,446 million pounds in 1954. This figure, compiled by the U. S. Tariff Commission, compares favorably with the 11,147 million pounds reported for the previous year.

Total production of tar and tar crudes, together with crudes derived from petroleum and natural gas, amounted to 33,062 million pounds. The combined production of all synthetic organic chemicals and their raw materials amounted to 61,507 million pounds, as compared with 60,759 million pounds in 1953.

Petrofina Buys Interest In Ruhrs Refinery

Compagnie Financiere Belge de Petroles has acquired a 75-percent interest in the Ruhrbau, G. m. b. H., refinery at Muelheim in the Ruhr. The remaining 25-percent is being retained by Farbenfabriken Bayer Leverkusen, which originally owned 50 percent.

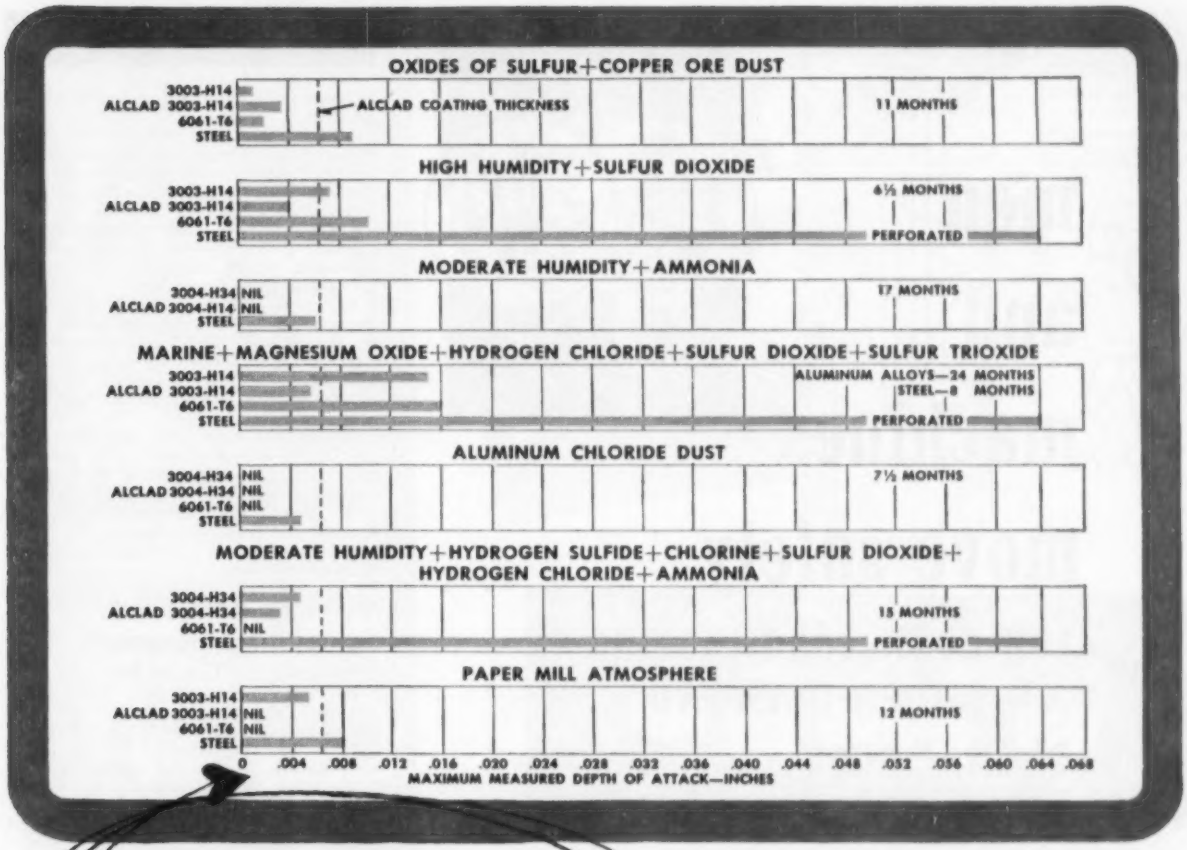
The refinery, a 2100-barrel-a-day plant, has been shut down because of a lack of profit. Since the Petrofina purchase, however, it is expected to be modernized. Its output, chiefly gasoline, distillates and heavy fuel oils, will be sold by another Petrofina company.

Average Octane Ratings Unchanged from September

The average antiknock quality of gasoline sold at service stations in October was unchanged from the September national weighted averages of 96 octane number for premium and 88.8 octane number for regular, according to a survey by Ethyl Corporation.

The October showing followed a broad advance for both gasoline grades between January and September, in which premium gasoline increased 1.7 octane numbers and regular increased 1.6 octane numbers. Compared with a year ago, premium and regular in October were both 1.9 octane numbers higher.

Average tetraethyl lead contents in September were 2.59 ml per gallon of premium



Resistance of ALCOA Aluminum alloys to certain atmospheric contaminants, compared with steel

Data for this chart were collected in various chemical plants. Bars indicate maximum measured depth of attack, in inches. Duration of exposure test is indicated on chart.

This exposure test proves ALCOA Aluminum resists refinery atmospheres

The most important property ALCOA Aluminum has to offer to the chemical and process industries is its high resistance to corrosion. Significant savings based on longer life, reduced maintenance and less down time are a direct result of the intelligent use of ALCOA Aluminum in these industries.

For example, aluminum alloys have been used for many years for process equipment by the ammonium nitrate industry, but only recently has the economy of the use of structural aluminum been recognized. It is becoming standard to specify aluminum structurals, grating, tread plate, conduit, electrical fittings, etc., in plants handling ammonium nitrate as well as other chemicals.

ALCOA's coordinated research and development program is geared to help you with *your* specific problems . . . to show you where and how aluminum can be used most effectively in your operations. Write today for details.

Investigate ALCOA Aluminum today. Get all the facts. They're in the new, FREE double reprint, *Resistance of Aluminum Alloys to Weathering* and *Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres*. Use the coupon at right to obtain your copy. We also have a new booklet, *Aluminum Pipe and Fittings*. Send for it.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Aluminum Company of America
905-L Alcoa Building
Pittsburgh 19, Pennsylvania

Please send me your new, FREE reprint, *Resistance of Aluminum Alloys to Weathering* and *Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres*. Also, *Aluminum Pipe and Fittings*.

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Company _____

Address _____

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One-half actual size

men
and
machines
move safely
over

• LOW-COST • LONG-LASTING
A.W. SUPER-DIAMOND
Rolled Steel Floor Plate

Where safety and economy are "musts"—no other floor plate can match SUPER-DIAMOND's rolled steel ruggedness and easy maintenance for so low a cost.

At every step 40 steel diamonds guard constantly against skids and slips. This non-directional pattern floor plate fabricates easily . . . can be installed overnight . . . gives years of dependable safety under the heaviest industrial loads.

Mail coupon for full details on this low-cost, long-lasting rolled steel floor plate.

A.W. SUPER-DIAMOND
ROLLED STEEL FLOOR PLATE

"The diamond in the rough . . . a gem of a flooring."

ALAN WOOD STEEL COMPANY
Conshohocken, Pa.

Please send A.W. SUPER-DIAMOND Booklet D-27
Name
Title
Company
Address
City Zone State

Other products: A.W. ALGRIP Abrasive Rolled Steel Floor Plate—Plates—Sheets—Strip—(Alloy and Special Grades)

For plants where oil, water and grease raise special problems of slipping accidents, we suggest a check on the special qualities of A.W. ALGRIP . . . the world's only abrasive rolled steel flooring.

What's Happening. . .

gasoline and 2.30 ml per gallon of regular gasoline.

Thirty-one of the 53 cities covered by Ethyl's survey reported increases over September in the average octane number of their premium gasolines, with eight of these cities showing a monthly gain of 0.5 octane number or more. Eighteen cities reported a decrease in average premium antiknock quality, while four cities were unchanged from September.

In regular gasoline, 19 cities reported increases in their average antiknock quality, five of them by 0.5 octane number or more. Thirty-one cities showed a decrease from September in the average antiknock quality of their regular, while three cities were unchanged.

Against the nationwide premium average of 96 octane number, 17 cities reported premium averages of 96.5 octane number or higher. In regular gasoline, 15 cities showed average octane ratings of 89.5 octane number or higher, compared with the national weighted average of 88.8 octane number.

Michigan Refineries Completing Merger

Stockholders of Leonard Refineries, Inc., have approved the purchase of two other Michigan refining companies, Mid-West Refineries and Roosevelt Oil and Refining Corporation. The merger agreement previously had been approved by stockholders in the other two companies.

Shares in the Leonard company will be distributed to Mid-West and Roosevelt stockholders in exchange for their present holdings. Leonard plans to make application for listing its common stock on the American stock exchange.

The three companies represent a total refining capacity of 31,500 barrels a day. Facilities include catalytic cracking at the Leonard refinery at Alma, Mich., and reforming at Mid-West's Alma refinery and the Roosevelt plant in Mount Pleasant. In addition, Leonard is building a 3600-barrel-a-day Ultraformer at Alma and a 5200-barrel-a-day Hydrofiner.

Underground-Storage Cavity Mined in Chalk

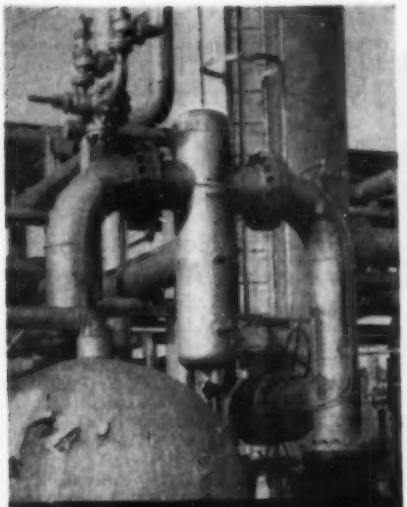
Two Tulsa LPG concerns are mining a 8.5-million-gallon underground-storage cavity near Demopolis, Ala. They are Tuloma Gas Products Company and Sinclair Oil & Gas Company. The cavity, to be mined in Selma chalk, will be drilled to 300 feet and set with 42-inch casing.

Storage tunnels will be mined laterally from the bottom of the shaft throughout the surrounding area. Some 500,000 yards of chalk will be removed before the cavity is ready for storage in May 1956. It is the first time an underground storage cavity has been mined in chalk.

Synthetic-Rubber Output Is 92,500 Tons for August

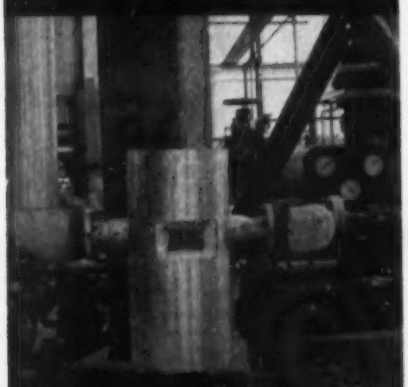
August synthetic-rubber production in non-Communist countries ran 92,500 tons, with consumption hitting 82,500 tons, the Department of Commerce has reported. In August 1954 production was 56,841 tons and consumption 50,000 tons.

World natural rubber production in August was 165,000 tons, compared with



A Peerless Line Separator is shown above removing entrainment from a refinery reboiler.

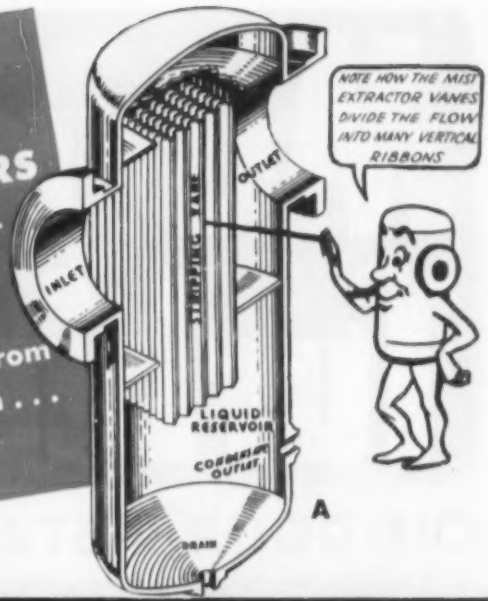
Peerless Line Separators are doing an effective job of mist extraction at this Kentucky Petrochemical Plant.



This is an insulated Peerless Steam Separator on a turbine driving an airblower.

PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .



HIGH EFFICIENCY — HIGH CAPACITY LOW PRESSURE DROP

Thousands of installations throughout the Refining and Chemical industry have proven the Peerless Line Separator principle to be one of the most outstanding methods available for the extraction of liquid from gas, steam or air.

Drawing A above shows the arrangement of the vanes in the Separator. Drawing B is an illustration of the Peerless principle.

The mist extractor combines the forces of impingement, centrifugal motion and surface tension to obtain its high efficiency. The path of the gas, etc., through the unit is constantly bending, causing semi-violent turbulence and rolling of the gas against the walls of the vane. Impingement and centrifugal force combine to contact the droplets with the vanes, where they coalesce, and surface tension then causes them to cling to the vanes' surfaces. Gravity and the impact of the gas stream then drives the droplets into the pockets where they roll down the vanes and out of the gas stream.

Through the Peerless method of mist extraction, the gas is stripped dry long before reaching the end of the vanes.

there's A PEERLESS SEPARATOR FOR EVERY REQUIREMENT

For any capacity
For any working pressure
For corrosive conditions
With removable vane units
With extra body length
With connections for accessory equipment
For pressure drop requirements of less than 6" water
For any vapor-liquid ratio
For any piping requirement

SPECIAL DESIGN SEPARATORS FOR ANY REQUIREMENT

FOR FURTHER INFORMATION ON THE USE OF PEERLESS LINE SEPARATORS PLEASE WRITE FOR NAME OF NEAREST PEERLESS ENGINEER.

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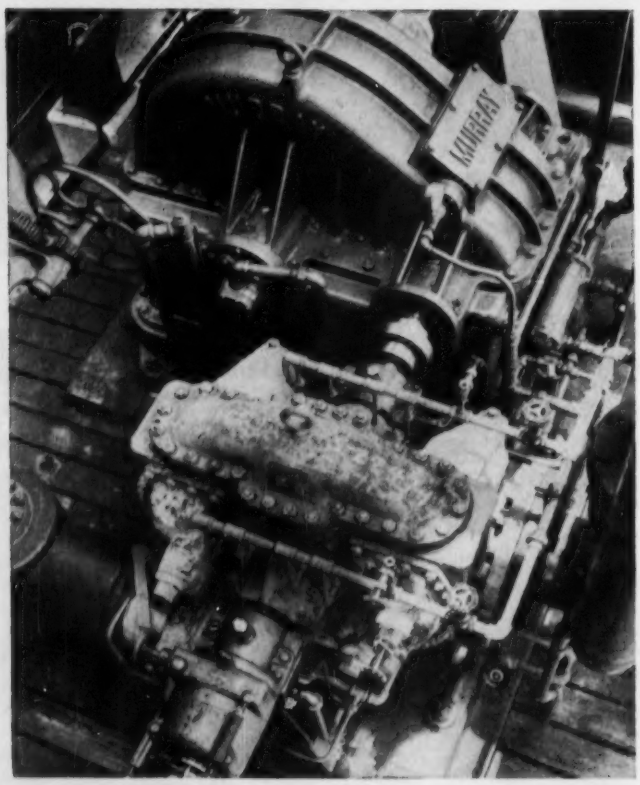
Murray Turbines

OUTDOOR INSTALLATION?



THE RIGHT ANSWER—MURRAY

The turbo-gear unit shown above has been installed outdoors with virtually no weather protection for many years. The turbine exhausts to a process line carrying 170 psig pressure. Yes—for rugged applications—the right answer—MURRAY.

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

What's Happening. . .

145,00 in August 1954. Consumption of natural rubber in August was estimated at 142,000 tons, against 130,000 tons for that period a year ago.

API Forms New Division For Finance Accounting

American Petroleum Institute has created a new division, known as the Division of Finance and Accounting, to replace its 30-year-old Financial and Accounting Committee. A vice president for the new division will be appointed by the API's board chairman.

Reasons for the organizational change were as follows:

- To recognize within the API the evolutionary advances which have taken place in the corporate financial and accounting structure of the oil industry.
- To bring within the democratic framework of the institute organization the industry's enlarged and continuously expanding financial and accounting functions.
- To give the Financial and Accounting organization sufficient depth and breadth to enable it to assume appropriate responsibilities on an industry basis.

API Group Issues Kit For Safe-Driving Day

To continue a positive highway-safety program, the American Petroleum Industries Committee has released an eight-section publicity kit for oil industry participation in Safe Driving Day, December 1, 1955.

Keyed to the slogan "Safe Drivers Make Safe Highways," the API kit contains material for individual company use in supporting S-D Day. Included are a mass distribution handbook that can be used as a bill-stuffer or throw-away; a series of four matted advertisement-features stressing expert driving tips; a newspaper safety contest; editorials; radio and TV spots; news releases; speech material, and a descriptive fact sheet.

Thirty days of public educational activity will precede S-D Day with national, state and local organizations joining to combat traffic accidents.

A kit can be obtained from the American Petroleum Industries Committee, 50 West 50th Street, New York 20.

Shell Backs Fellowship For High-School Teachers

To help support science teaching at the secondary level, Shell Companies Foundation, Inc., has set up a program of recognition fellowships for high-school teachers of science and mathematics. Through the program, Shell will underwrite summer seminars at Stanford and Cornell Universities for 60 teachers a year.

The recipients, chosen on the basis of merit and demonstrated leadership qualities, will receive travel allowances, all tuition and fees, living expenses on the campus and $500 cash to make up for the loss of potential summer earnings. The program will be known as the Shell Merit Fellowships for High School Science and Mathematics Teachers.

• *Stymied by a*
High-Temperature Barrier?

• *Looking for a*
High-Purity Material?

• *Searching for a material with*
Unusual Electrical Characteristics?

You may find the answer in this new booklet on NORTON Refractory Grain

This latest Norton publication is 8½" x 11". Twenty-four pages, with many charts, tables and photographs in color. A wealth of practical information on the nature, performance and application of refractory grains.

IF you're concerned with industrial processing involving temperatures ranging upwards to 4000°C and materials to contain your inferno — if you're looking for a high-purity material such as high-purity fused alumina for coating electronic heater filaments — if you're searching for a material with unusual electrical characteristics such as E 179 CRYSTOLON* Silicon Carbide for lightning arrestors — one of the many types of Norton Refractory Grain available may solve your problem.

This new booklet describes in detail Norton Refractory Grain — produced and purified in electric arc and high temperature resistance furnaces — which is helping industry to improve existing products and processes and to create new ones.

It's a valuable reference book with up-to-the-minute information on the chemical and physical characteristics of such materials as CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, Fused Zirconia and Boron Carbide. In it you'll find data on how these materials are produced; their behavior under varying conditions; available grain size and applications.

These electrochemically refined materials may be just what you've been looking for to solve your problem. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 470 New Bond Street, Worcester 6, Mass.

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REFRACTORIES
Engineered... Rx ... Prescribed

Making better products... to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

R. S. Douglass has been named superintendent of the Shell Oil Company refinery at Norco, La. He succeeds **L. T. Wilson**, who was named manager of the Montreal, Queb., refinery operated by Shell Oil Company of Canada, a wholly-owned subsidiary.

For the past nine years, Douglass has been assistant manager of the Manufacturing Engineering department in Shell's head office in New York. He joined the company in 1927 at the Wood River, Ill., refinery.

After working in capacities of increasing responsibilities in Houston and St. Louis, he became chief engineer at the Norco refinery in 1937. Later he was chief engineer at the Houston refinery before taking over his recent post in New York.

Edgar F. Ackerman, since 1952 chief chemist and engineer for Consolidated Chemical Industries, Inc., at Bastrop, La., has been named superintendent of the company's Little Rock, Ark., plant. He is one of three receiving promotions to executive positions in the Consolidated organization.

A. L. Sweitzer, formerly a buyer and assistant purchasing agent, was moved up to succeed W. G. Roberts as purchasing agent for the Southern division headquartered in Houston. Roberts recently retired.

E. J. Creider was named assistant manager at the Consolidated plant in Fort Worth, Texas. He will be transferred from Little Rock.

Lyle R. Duty, formerly administrative assistant to the president of Pan-Am Southern Corporation, has been elected secretary of the company. He succeeds P. J. Schowalter, deceased.

A specialist in office methods and procedures, Duty started with Pan-Am Southern on a temporary loan basis from Standard Oil Company (Indiana), Pan-Am's parent company, in 1950. The following year he was given a full-time assignment as assistant to the executive vice president, and in June 1952 he was made administrative assistant to the president.

Alberto F. Thompson has been named to head the National Science Foundation's Office of Scientific Information. Dr. Thompson joined the foundation after seven years as chief of technical information for AEC. He was in charge of the U. S. exhibit at the International Conference on the Peaceful Uses of Atomic Energy at Geneva, and during World War II he was assigned to the Manhattan District.

Merrel R. Fenske, director of the Petroleum Refining Laboratory at Pennsylvania State University, was honored by Pennsylvania Grade Crude Oil Association at a recent celebration marking 25 years of petroleum research. Dr. Fenske has been in charge of the association's research in petroleum refining at Penn State since the program was launched in 1930, to develop new ways of identifying pure Pennsylvania oils.

Horton

Kaul

Allen W. Horton, Jr., has been elected secretary-treasurer of Oronite Chemical Company, and **Walter C. Kaul** was named comptroller. Both appointments were made in line with administrative realignments following the recent death of Oronite's secretary-treasurer, **B. W. Anthony.**

Horton formerly was chief analyst in Standard Oil Company of California's Comptrollers' department. Kaul was an assistant treasurer of the subsidiary Oronite company. He was transferred from California Standard in 1945.

Paul L. Berkman, a research associate at Columbia University's Bureau of Applied Social Research, has joined the API's Department of Information. He will coordinate the various surveys undertaken by the Department and the Oil Industry Information Committee. His studies and reports will help the committee plan its nationwide public relations program.

During his three years with the Bureau of Applied Social Research, Berkman studied motivation factors involving people behind the Iron Curtain, in the Middle East, and in this country. During World War II, he was a lieutenant commander in the U. S. Navy. He is a graduate of Minnesota State Teachers College and the National War College, and has done graduate work at the University of Chicago and Columbia University.

G. Davidson, manager of the Shell Oil Company of Canada refinery at Montreal East, has been elected vice president in charge of manufacturing. He replaces **D. M. Morrison,** recently elected president of Trans Mountain Oil Pipe Line Company.

Hardman | Jones | Strecker | Veatch | Darling | Stine

Sohio Makes Eight New Research Assignments

Two new additions to the staff and six promotions have been made in the Chemical and Physical Research division of The Standard Oil Company (Ohio) at Cleveland.

E. O. Hook, formerly with the American Cyanamid Company at Stamford, Connecticut, has joined Sohio's research staff as coordinator of the Mobile Power Lubricants and the Mobile Power Fuels Process sections at Sohio Research Laboratory. Dr. Hook is a graduate of Oberlin College and received his Ph.D. degree from Yale.

Hook

W. S. McClenahan, formerly with the Mellon Institute in Pittsburgh, becomes coordinator for the Petrochemicals Industrial Products and Basic Research Sections in the Sohio Research Laboratories. He is a graduate of Carleton College and received his Ph.D degree from Massachusetts Institute of Technology.

McClenahan

Harry M. Stine, with Sohio since 1938, becomes administrative supervisor in Sohio's Chemical and Physical Research division. He is a graduate of Purdue University and holds a Ph.D. degree from Western Reserve University.

S. M. Darling has been promoted to section supervisor in the Mobile Power Lubricants section. He has been with Sohio since 1939, is a chemical engineering graduate of Carleton College and holds a doctor's degree from Western Reserve University.

Frank Veatch, with Sohio since 1942, a graduate of the University of Arizona

PETROLEUM CHEMICALS DIVISION

NEWS

November ★ One of a Series of Interest to the Petroleum Industry ★ 1955

NEW DU PONT TEL PLANT NOW UNDER CONSTRUCTION IN CALIFORNIA

On August 24, near Antioch, California, the ground was officially broken for construction of Du Pont's new West Coast tetraethyl lead manufacturing plant. Many local Antioch dignitaries were on hand for the ground breaking ceremony.

This California plant site has much to recommend its choice by Du Pont . . . including the local availability of necessary labor skills, its convenient location in the heart of a growing market for TEL, adequate supplies of power and good water, plus the option of water or rail shipments.

In addition to employing the most modern continuous process methods of manufacturing TEL, the new plant will include a unique new waste disposal system. The waste materials will be discharged into a deep underground well – in excess of 6,000 feet to eliminate any danger of contaminating surface water.

A new plant for manufacturing Du Pont "FREON" is also being built on the Antioch site.

Two lube oil additives to help you sell fleet contracts

For refiners interested in fleet contracts, Du Pont's two polymeric lube oil additives offer special sales advantages, especially with owners of fleets in low-duty, stop-and-start use.

Du Pont Lube Oil Additive 564 and Du Pont Lube Oil Additive 565 provide an economical and effective means of preventing engine oil sludge. They are particularly effective under low-temperature, low-power, stop-and-go driving conditions. Both work as detergents and V. I. improvers.

LOA-564, with its lower molecular weight gives an engine oil with excellent shear stability. The higher molecular weight of LOA-565 gives greater viscosity index improvement.

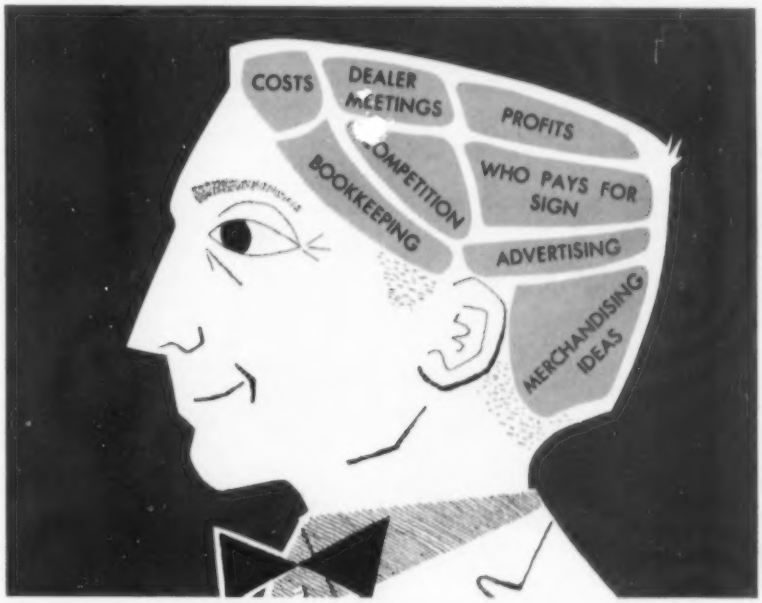
Both are ashless. They keep engine oil systems clean and free of sludge under severe conditions . . . contribute to longer engine life.

Besides providing extra sales appeal for fleet customers, the benefits of these additives offer exceptional promotion and marketing opportunities with the mass passenger car field. Information and samples are available through your Du Pont representative or sales office.

What Do Your Dealers Really Think...

Of your dealer meetings? . . . Your advertising? . . . Your dealer publications and sales promotion aids?

Report No. 3 of the new Du Pont survey—"The Service Station Operator"—is now off the press. If you want to get behind the scene at the pump island and study the effect of your promotion program on your dealers, you'll surely want to take an early peek at the results of this survey.



Increasing the merchandising savvy of the service station operator is probably the chief objective of all dealer training and promotion programs. But to achieve this, you first need the interest and cooperation of the dealers themselves.

The index of this interest and cooperation can be found, we believe, in the dealers' answers to questions asked them in this recent dealer survey.

Are they helpful?

The dealers were asked how many meetings their company invited them to each year . . . and how many of these they attended. Their answers, you'll find in the survey report, ranged all the way from none to a baker's dozen. But what was accomplished at these meetings is the most important thing.

You'll be glad to know that a large majority of them found the meetings *helpful*. How? Their answers ranged all the way from "sales tips" to "news of trade." And the survey report will also tell you what parts of the program are actually *put to work at the station* by the dealers.

What they want

Some dealers, the survey found, would like to have their supplier companies do *more* for them. And they listed several things specifically. Station modernization was one of the things most frequently mentioned. Many of them also indicated they would like to see revisions in the companies' advertising.

Telling is selling

How do the dealers feel about their supplier's policies on rental arrangements, advertising, competitive pric-

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

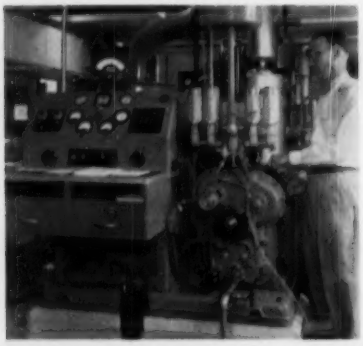
OVER

PETROLEUM CHEMICALS DIVISION
NEWS

New, Modern Regional Laboratory at Tulsa

A complete modernization program has just been completed at the Du Pont Mid-Continent regional laboratory in Tulsa, Oklahoma. The photographs below show how the air-conditioned lab building has been modernized and new equipment added. Improved customer service is the objective.

Over-all view of the new regional laboratory interior. You can also see from this picture that the regional lab people take considerable care with their housekeeping.



H. M. Carey operating the Tulsa lab's new CFR octane number test engine.

The new set-up at the laboratory for analyzing copper, antioxidant and metal deactivator content. This equipment is also used for color work. Blake Partain is shown in the foreground.

MID-CONTINENT REGIONAL LAB MANAGER

E. ODELL CAMPBELL joined the Du Pont Petroleum Chemicals Division in 1951. Since that time he has managed the Division's Mid-Continent regional laboratory in Tulsa, Oklahoma. He is in charge of Du Pont customer service, product testing, and additives treating recommendations in the region.

Following college, he did general petroleum testing, and later was made a Petroleum Chemist in charge of a phase of the research work at the Bureau of Mines Petroleum Experimental Station in Bartlesville.

During World War II he was a commissioned officer in the U. S. Navy. From 1945 to 1951 he served with the Munitions Board. There his job as a chemical engineer included petroleum planning and coordination of technical petroleum problems for the three military services.

Mr. Campbell received his B. A. degree in Chemistry at the University of Oklahoma, and later studied at the University of Arizona and George Washington University. He is a member of the American Chemical Society, Alpha Chi Sigma Fraternity, and the American Association for the Advancement of Science.

E. ODELL CAMPBELL

CONTINUED

Dealer Survey

ing, training programs, etc.? In general, when the dealers know and understand these policies, they like them. However, a large number of dealers, so the survey found, are not aware of their supplier's policies on these matters.

In addition to the above areas, this Report No. 3 delves into the dealer's opinions of dealer publications, overall company advertising and point-of-sale merchandising displays. Their opinions of supplier representatives are also documented. And the report includes information on the dealer's own advertising programs, too.

Complete series of reports

The previous two reports in the series cover (1) such dealer retail functions as station hours, gallonage, credit and mailing lists; and (2) dealer knowledge of products, additives, sales assets and prices. Future reports, to be published soon, will discuss (4) employee-dealer relationships, dealer associations, his educational background and income; and (5) the interrelationship of all the above factors . . . such as how station hours, dealer meetings and education affect sales volume.

Continuing market research

Sponsored by Du Pont, the survey was conducted on a completely impartial basis by National Analysts, Inc. It is nationwide in scope and part of the continuing market research work of the Du Pont Petroleum Chemicals Division. It follows the recent Du Pont survey of service station customer buying habits.

For more information about this survey, just get in touch with any of our representatives or sales offices listed below.

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Better Things for Better Living
. . . through Chemistry

Petroleum Chemicals

E. I. DU PONT DE NEMOURS & COMPANY (INC.) *Petroleum Chemicals Division • Wilmington 98, Delaware*

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PITTSBURGH, PA.—Room 510, Alcoa Bldg. Phone ATlantic 1-2933
SAN FRANCISCO, CAL.—Room 626, 111 Sutter St., Phone EXbrook 2-6230
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A-277

Printed in U. S. A.

What's Happening. . .

and with a Ph.D. degree from Stanford University, has been made section supervisor in Sohio's Petrochemical section.

A. L. Jones, with Sohio since 1946, has been promoted to section supervisor of Sohio's Basic Research section. He is a graduate of Hampden-Sydney College, received a doctorate at the University of Virginia, and served as an instructor at Cornell University before joining Sohio.

H. A. Strecker, who received his B.A. degree and his Ph.D. degree from Cornell University and who joined Sohio in 1947, has been made section leader in the Mobile Power Fuels Process section.

H. A. Hardman, with B.S. and M.S. degrees from West Virginia University, has been promoted to senior research associate in the Industrial Products section of Sohio's Research Laboratories. He has been with Sohio since 1946.

Fred Adams, president of G. M. Basford Company, has been elected to the board of directors of Sun Chemical Corporation.

Walter V. Stearns has been named to a newly-created position as chief petroleum engineer for The H. K. Ferguson Company. He will coordinate and supervise specialized process design work in the company's major engineering offices.

Stearns

Registered as a professional engineer in New York and Ohio, Stearns is a Harvard University graduate with a degree in chemistry and a master's degree in industrial chemistry. He has been active in design process for more than 25 years.

Carl Bussow, with A. W. Dow, Inc., in New York, has been elected president of the Association of Consulting Chemists and Chemical Engineers, Inc. Named to serve as vice president for the coming year was **Foster D. Snell**, president of Foster D. Snell, Inc., also in New York.

Earl D. Stewart, director of research for Schwartz Lab., Inc., at Mount Vernon, N. Y., was elected secretary, and **William C. Bowden**, secretary-treasurer of Ledox and Company, Inc., a Teaneck, N. J., firm of metallurgists, was made treasurer.

T. H. Barton has been elected to the Finance committee of Monsanto Chemical Company. He was chairman of the board of Lion Oil Company before its recent merger with Monsanto. When the two companies merged, he was elected to the Monsanto board.

Barton, already established in the Arkansas natural-gas industry, became president and director of Lion's predecessor, Lion Oil Refining Company, in 1929. He served as president until 1947 when he became chairman of the board.

G. R. L. Shepherd has been promoted to section head in the Research & Development division at Humble Oil & Refining Company's Baytown, Texas, refinery. He will head a section responsible for re-

It's easy to keep "CAT" cracking units purring . . . with Yorkmesh Demisters in your charge preparation equipment guarding the quality of your gas oil. Separation efficiencies exceeding 99.9%, with corresponding reductions in contaminating impurities and carbon content are assured even at high vapor velocities and with negligible pressure drop.

Yorkmesh Demisters are tailor-made for quick installation in new or existing equipment. On receipt of operating data and equipment arrangement, York engineers will make specific recommendations as to the size, type and material of the demister needed to improve the performance and increase the throughput capacity of any process vessel handling both liquid and vapor phase materials.

For specific details on reducing catalyst poisoning write for case study #1002 . . . for the complete story on Yorkmesh Demisters ask for bulletin #16.

Simple as spelling C-A-T

Contaminated with fine liquid droplets the vapor rises through the tower.

As the vapor stream passes through the fine wire mesh, the droplets impinge on the wire surfaces, coalesce into large drops and fall off.

The vapor is now dry and free from impurities.

Yorkmesh Demisters provide clean separation between liquid and vapor in:

Vacuum towers • Distillation Equipment
Gas Absorbers • Scrubbers • Evaporators
Knock-Out Drums • Steam Drums

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YORK PROCESS EQUIPMENT CORP.
4 CENTRAL AVENUE · WEST ORANGE, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

FLEXON METAL HOSE *Operating Briefs*

Now, Greater Dependability, Longer Life for Flex Connections with New Stainless Steel Rex-Weld

Make your Selection Here...

I.D. (In.)	Nominal O.D. (In.)		Minimum Inside Bend Diameter (In.)		Burst Pressure	Weight Per Foot (lbs.)	
	RW 80	RW 81	Repeated Flexing	Static Bend	(psi)	RW 80	RW 81
¼	½	⅝	12	7¾	16,500	.20	.36
⅜	11/16	13/16	14	10¼	14,000	.27	.41
½	27/32	31/32	16	11	12,400	.47	.65
¾	1 7/64	1 13/32	21	17	10,500	.90	1.33
1	1 35/64	1 11/16	26	18	8,500	1.04	1.59
1¼	1 57/64	2 1/16	30	21	7,600	1.81	2.39
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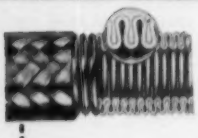
2	2 57/64	3 5/64	44	24	4,650	2.97	3.78



RW-80 is unbraided, RW-81 has stainless steel braid. A complete selection of factory-attached fittings is available to meet all requirements. Data on larger sizes (to 6" I.D.) available on request.

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What's Happening...

search in alkylation, polymerization, hydrogenation, hydrocracking, isomerization, photochemical reactions and other related processes. Shepherd holds B. S. and M. S. degrees in chemical engineering from Georgia Institute of Technology.

C. M. Floyd has been named senior research chemical engineer in the Research and Development division of the Humble Oil & Refining Company refinery at Baytown, Texas. He will be engaged in field test work in which the performance of lubricants are studied. Floyd received a B. S. degree in chemical engineering from the University of Texas in 1930.

William B. Borst has been made coordinator of construction and refining for Ashland Oil & Refining Company. He has been superintendent of the company's 25,000-barrel-a-day Canton, Ohio, refinery since 1947.

Borst

Borst has been at the Canton plant since 1936, when he started as a chemist with Alco Refining Company. He became assistant superintendent in 1937, when the refinery was taken over by Allied Oil Company, now an Ashland subsidiary.

A graduate of the University of Illinois, he was research chemist with Universal Oil Products Company five years, and before going to Canton he was chief treater at the Big West Oil Company refinery in Keirn, Mont. He is licensed as a chemical engineer in Ohio.

Harry D. Gasarch has been appointed assistant comptroller for Socony Mobil Oil Company, Inc. He has been manager of the comptroller's Foreign department since 1953, spending nearly half his time on assignments in Western Europe, West Africa and the Middle East.

Gasarch joined Socony Mobil in 1929 as a junior clerk in the Domestic Trade staff and in 1951, became manager of accounting and statistics reviews. He was coordinator for the subcommittee of the API Financial and Accounting committee, which wrote the *Outline of Petroleum Industry Accounting.*

A. E. Harnsberger, with The Pure Oil Company since 1924, has been moved up to a newly-created position as general manager for transportation and supply. He will have charge of a number of departments in those fields.

Since joining Pure, Harnsberger has been engaged primarily in the Refining division, having been a control-board member for many years, as well as chairman of that group. More recently he has been manager of the Refinery Technical department.

John F. Wright has been appointed assistant coordinator of chemical products for Standard Oil Company (New Jersey), which recently placed the worldwide petrochemical operations of its affiliated companies under central coordination. He will assist **Robert M. Jackson,** already

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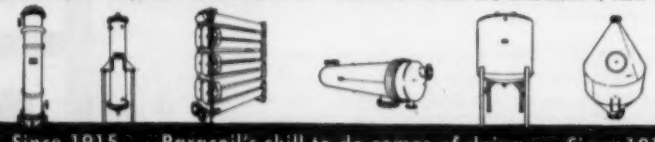

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What's Happening. . .

named as Jersey Standard's first chemical products coordinator.

Wright joined the Jersey Standard organization in 1936, and held various technical and supervisory positions at the Esso Standard Oil Company refinery in Baton Rouge, La., until 1951 when he was transferred to Esso Standard's Bayway, N. J., refinery as head of the Technical department.

He became superintendent of the Chemical Products department at Bayway. in 1953. The following year he was appointed head of the Process department with responsibility for the refinery's manufacture of chemical as well as petroleum products.

Howard E. Hughes has been promoted to superintendent of Shell Chemical Corporation's Houston plant. Hughes, who has been serving as assistant superintendent-technical, replaces **Frank G. Watson,** named assistant to the vice president of manufacturing in the company's head offices in New York.

Hughes

Hughes joined Shell Chemical as a tester at the Martinez, Calif., plant in 1934. He became chief engineer at Dominguez, Calif., in 1944. He was transferred to Houston in 1951, and had been assistant superintendent there since 1954.

Robert H. Aitken, formerly superintendent of The Texas Company's Eagle Point Works at Westville, N. J., has been named to manage a newly-created Refining division. The division was set up to function as part of the Foreign Operations department.

Aitken joined Texaco in 1926 as a draftsman-engineer at the company's Lawrenceville, Ill., refinery, holding a succession of positions there until he was promoted to process engineer in 1941. The following year he was appointed assistant superintendent of the San Antonio Works and two years later was given a similar assignment at Lawrenceville.

In 1947 he undertook a special assignment with Carthage Hydrocol, Inc. He was named assistant superintendent of Texaco's Eagle Point Works in 1954, and later that year he was moved up to superintendent of the refinery.

Joseph R. Layton has been made manager of Sun Oil Company's Refinery Accounting department. He joined the company in 1947 as a senior clerk and since has held assignments as special assistant and assistant office manager in the Accounting department.

Robert W. Schiessler, associate professor of chemistry at Pennsylvania State University, has joined Socony Mobil Oil Company, Inc., as technical director in charge of the Research division at the company's Research and Development Laboratories in Paulsboro, N. J. He succeeds **Frederick L. Matthews,** who will become assistant to the technical director.

Other changes in key positions at the laboratories include the appointment of

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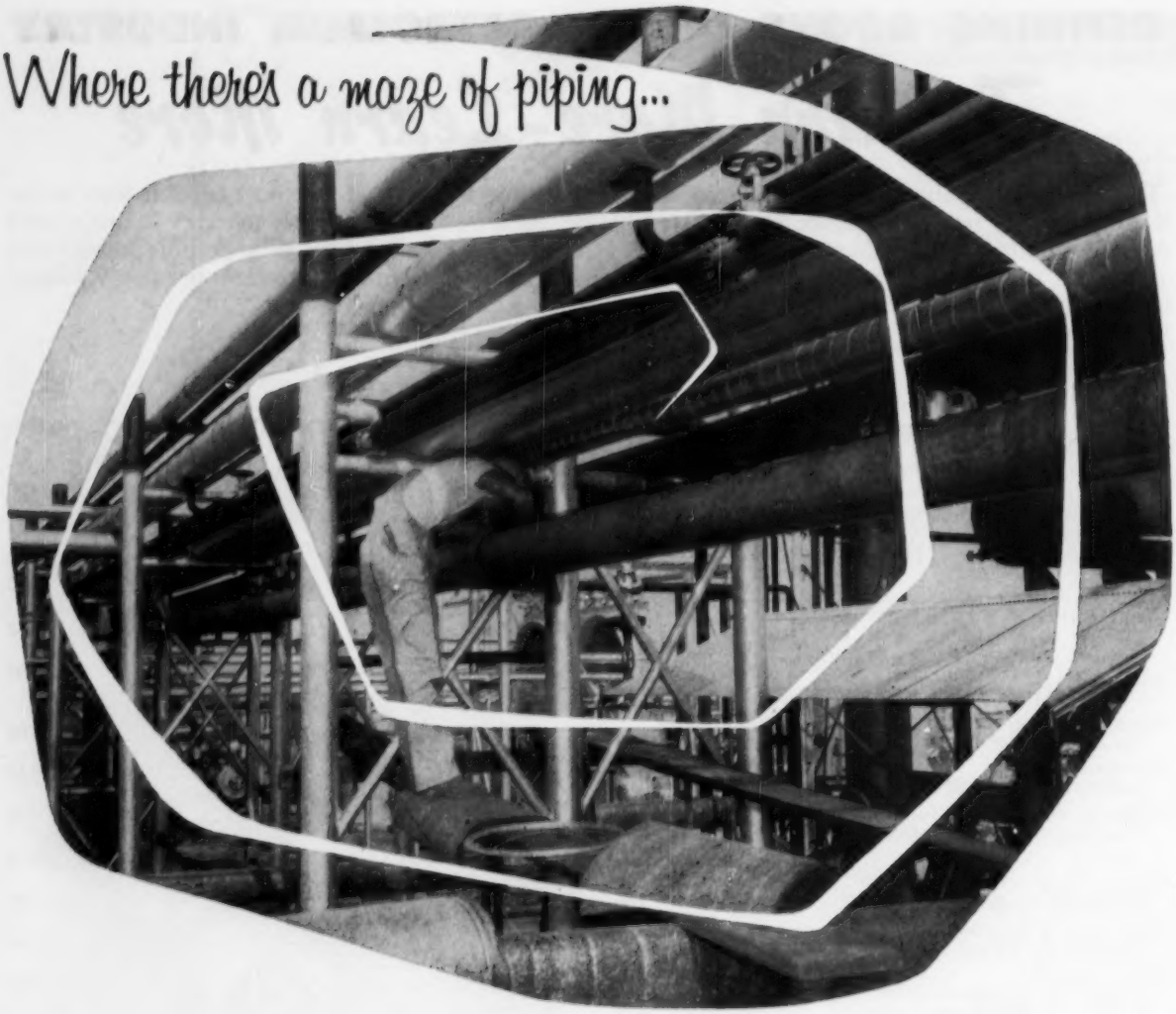

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Ralph E. Albright as technical director of the Products division, succeeding **George H. S. Snyder**. Snyder was named assistant to **Theodore W. Nelson**, director of the laboratories.

Edward A. Martin has been appointed assistant to the technical director of the Products division, and **Donald P. Heath** will succeed Albright as supervisor in charge of the Fuels section. **John F. Socolovsky** will take Martin's place as supervisor of the Automotive section, and **Leo W. Manley** will succeed Socolovsky as supervisor of the Lubricants section.

Horace H. Chandler, formerly assistant superintendent of The Texas Company's Eagle Point works at Westville, N. J., has been moved up to replace **R. H. Aitken** as superintendent of the refinery. Aitken was appointed manager of the Refining division in Texaco's Foreign Operations department.

Named as the plant's new assistant superintendent was **W. R. Sorenson**, assistant supervisor of the Process division in New York. Sorenson, who joined the company in 1937 at its refinery in Port Arthur, Texas, was appointed a process engineer in 1953 and transferred to New York. The following year he was promoted to assistant supervisor of the Process division.

Chandler, who has been with the company since 1932, started as a trainee at Port Arthur. He remained there until 1954 when he was promoted to assistant superintendent of the Eagle Point works.

E. Lawrence Morton has joined Esso Laboratories at Baton Rouge, La., as a chemical engineer. He recently received a B.Ch.E. degree from Georgia Institute of Technology.

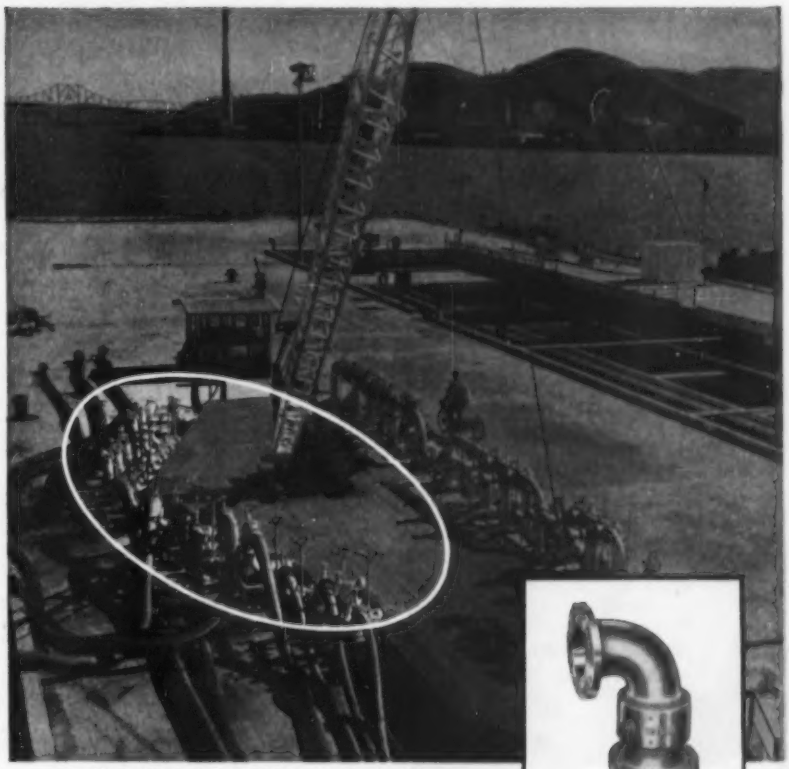
A. W. Goodwin, chemical engineer at the American Oil Company refinery in Texas City, Texas, has been promoted to head of the Research and Development department's Economics section, Previously assigned to the Technical Service staff, he had been serving as a group leader in the Economics section. Goodwin joined American Oil in 1946.

B. R. Banerjee has been advanced in the Standard Oil Company (Indiana) Engineering Research department at Whiting, Ind. With the company since 1951 and an assistant project engineer since 1953, he was named leader of the Diffraction group in the Material division's Physical Metallurgy section.

Dr. Banerjee, a native of India and graduate of the University of Calcutta, holds master's and doctor's degrees in metallurgy from Yale University. He has taught at Illinois Institute of Technology and the University of Calcutta.

Paul W. Bachman has been elected vice president and director of research and development for Koppers Company, Inc. He will direct the company's technical research and development, and carry responsibility for setting its research policies. E. W. Volkmann, who has been manager of the Research department since early 1955, will continue in that position.

Under the new organization providing for a research director as well as a manager of the Research department, Dr.



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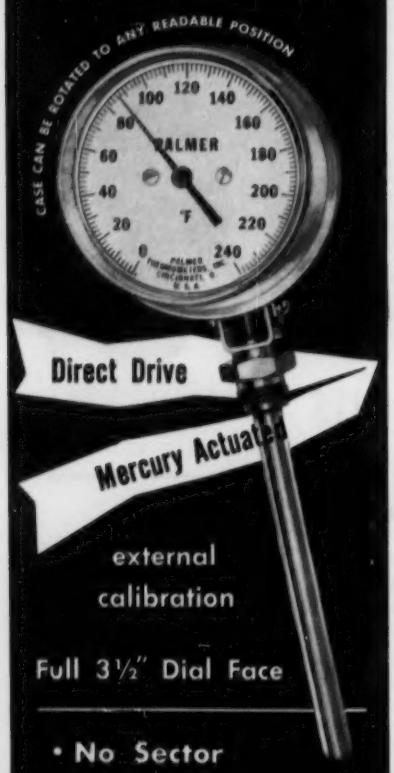

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Bachman will be free of much administrative work and able to devote most of his time to the development of research-born products. Dr. Volkmann will continue his duties in carrying out research activities at the company's Verona, Pa., research center and operate laboratories operated by Koppers.

Dr. Bachman had been associated with the research programs of General Chemical Company and Victor Chemical Company, when he joined Davison Chemical Company in 1949 as director of research and development. He was made a vice president of that company in 1952 and in that capacity was responsible for reorganizing its research and development program.

Paul A. Demkovich has been appointed group leader in the Standard Oil Company (Indiana) research laboratories at Whiting, Ind. He will be in charge of the Analytical Development group in the Analytical and Inspection division. Demkovich started with Standard as a chemist in 1947.

D. J. Stark, formerly manager of the National Petrochemical Corporation plant at Tuscola, Ill., has been named to manage the $25-million petrochemical plant Escambia Bay Chemical Corporation is building at Pensacola, Fla.

Stark was with Shell Oil Company before joining National Petrochemicals in 1951 as manager of the Tuscola plant. For a number of years he was chief technologist and department manager in charge of catalytic cracking for Shell Oil Company of Canada at its Montreal East refinery.

John M. Evans, chief engineer for Standard Oil Company of California, has completed 40 years with the company. He joined the company's Engineering department in 1915 and has been chief engineer since 1947.

William O. Barnes has been appointed industrial relations supervisor for the Eastern Division, Tide Water Associated Oil Company. He succeeds Seth W. Candee who is retiring after 30 years of service with the company.

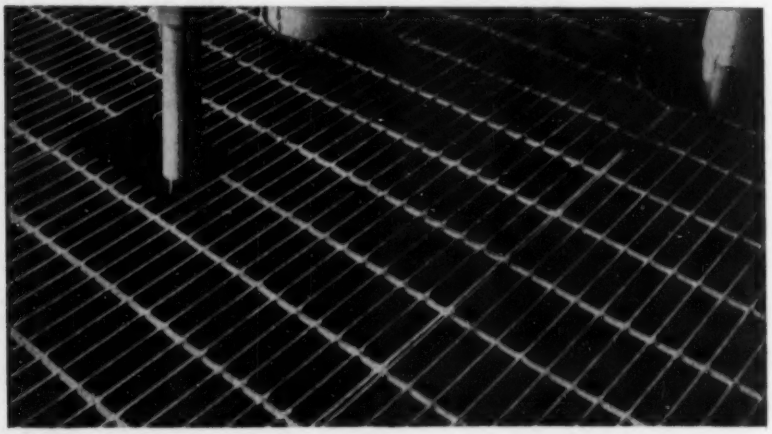
Barnes

Barnes started with the company in 1925 at its refinery at Associated Calif. In 1936 he became employe relations supervisor at Avon.

W. A. Reaman has been made assistant manufacturing advisor for International Petroleum Company, Ltd. He will be succeeded as head of the company's Refining department at Talara, Peru, by **G. M. Stedwill,** formerly chief chemist at Talara.

Also receiving a new assignment in the Standard Oil Company (New Jersey) affiliate is **W. A. Lockwood,** named senior economic analyst. He formerly was economic analyst in the Manufacturing department of Esso Standard Oil Company in New York. Lockwood served eight years at the Esso refinery in Baton Rouge, Louisiana.

Both Reaman and Stedwill joined International after service with its subsidiary Tropical Oil Company. Reaman, who is



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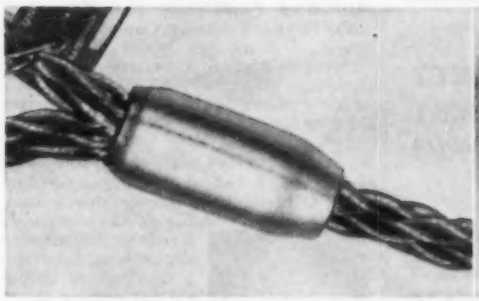
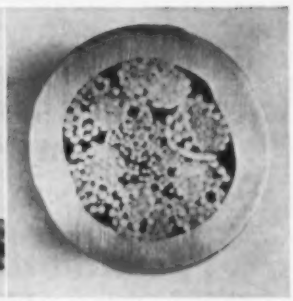


A heavy walled, streamlined steel ferrule is pressed on over tucked eye splice of Tuffy machine braided wire fabric from which sling is made.



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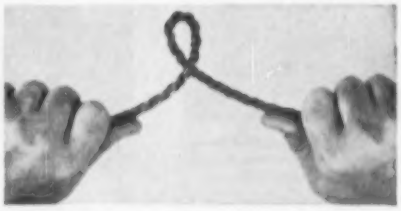

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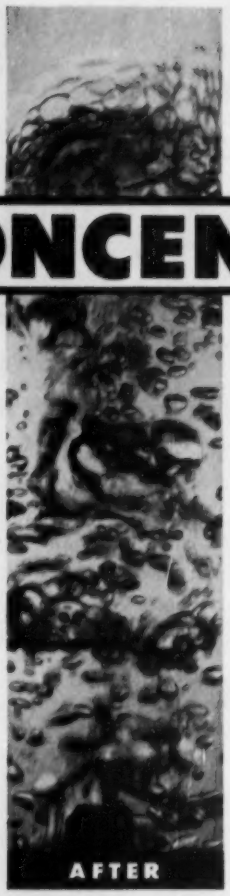

Laboratory demonstration shows foaming of highly alkaline solution in glass test cylinder.

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● Tests and plant operating records in all parts of the country have established the effectiveness and economy of Concentrol chemical treatment to combat wet steam problems. Where boiler water carryover is caused by foaming due to high alkalinity and high proportion of dissolved solids in the water, Concentrol is essentially a surface active agent that causes breakdown of bubble film, preventing foam formation.

Concentrol is supplied in liquid, powder or briquette form—can be fed either continuously or in slugs to boilers. Formulations of Concentrol can include organic sludge conditioning agents and other water treatment chemicals for boiler treatment as well as antifoam. Concentrol eliminates the need for costly pre-treatment of water and high blow-down rate. It is fast acting and resistant to hydrolysis or breakdown under normal boiler temperatures and pressures.

A Bird-Archer 8 Point Service Engineer is as near as your phone. For friendly counsel call him or write directly to Bird-Archer outlining the details of your boiler operations.

Engineering plus Chemistry equal Bird-Archer Service

BIRD-ARCHER WATER TREATMENT

THE BIRD-ARCHER COMPANY, 4337 NORTH AMERICAN ST., PHILADELPHIA 40, PA.

NEW YORK • CHICAGO

IN CANADA: The Bird-Archer Co., Limited, Cobourg, Ontario

IN MEXICO: Calderas y Accesorios, S. A., Amsterdam 291, Mexico, D. F.

What's Happening. . .

being transferred to the company's Coral Gables, Fla., offices, started with International in 1948 as chief process supervisor, and was made head of the Refining department in 1952.

Stedwill was transferred to International in 1947, after serving Tropical as chief chemist. He became process control supervisor at Talara in 1951 and the following year, was appointed chief chemist.

Anthony P. Massa, process engineer with H. K. Ferguson Company for the past four years, has joined the Refinery division of Bechtel Associates. Assigned to the New York staff, he will serve as a senior engineer in the Project Engineering department.

S. A. Guerrieri has been appointed to the technical staff of The Lummus Company, Guerrieri, who was one time a member of the company's Process Engineering department, later was a professor of chemical engineering at the University of Delaware and more recently was chief process engineer for Arthur G. McKee and Company. He will be concerned with general liaison with licensor companies, as well as participation in the general advisory and consulting functions of Lummus' Technical Staff department.

Guerrieri

Eger V. Murphree, president of Esso Research and Engineering Company, has received an honorary degree of Doctor of Engineering from Brooklyn Polytechnic Institute. He was cited as an engineer, scientist and administrator.

R. A. Cuthbertson heads a new Industrial Relations department set up by Cities Service Oil Company (Pa.). Secretary of the company since 1943, Cuthbertson continues to hold that position in addition to his new responsibilities.

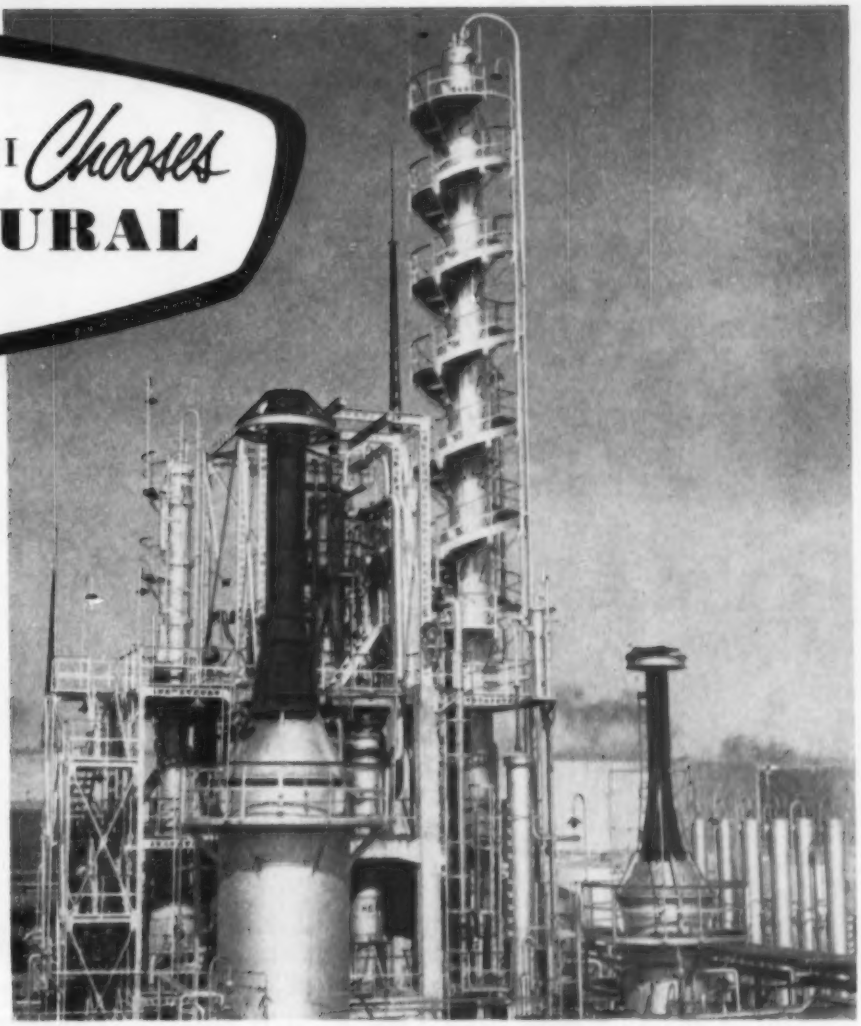
Leroy Page, a graduate of the University of Arkansas and holder of a B. S. degree in chemical engineering from the University of Oklahoma, has been awarded the Phillips Petroleum Company's $2000 fellowship in chemical engineering at the University of Oklahoma.

Carlton L. Horine, formerly senior production engineer and head of the China Lake Pilot Plant Division of Propellants and Explosives at the U. S. Naval Ordnance Test Station in Inyokern, Calif., has joined Brea Chemicals, Inc., as senior process engineer in its Development department.

J. C. Van Gundy, formerly assistant technologist with The Texas Company in Chicago, now heads a new Technical Service headquarters Texaco has opened in Pittsburgh. The new office will serve the iron, steel and aluminum industries and other manufacturers in that area.

With the company since 1935, Van Gundy has held assignment's to Texaco's Port Arthur, Texas, refinery, its Beacon,

MITSUBISHI *Chooses*
FURFURAL



Photograph of furfural unit in Mitsubishi's Kawasaki refinery where quality lubricating oil is produced.

why more and more oil refineries are using QO® FURFURAL

1. QO Furfural gives high yields of quality oil. The polar molecule is highly selective in its solvent action.

2. QO Furfural is readily recoverable. It is thermally stable under conditions of use and the experience of over 40 plants using furfural proves that solvent losses are low.

3. QO Furfural is readily available from raw materials which are replaceable annually.

4. QO Furfural's low freezing point of —34° F. assures trouble-free handling throughout the year.

5. QO Furfural requires no unusual precautions. It has a safety record extending over 30 years of industrial use.

For further information on QO Furfural, write for Bulletin 203-A.

The Quaker Oats Company CHEMICALS DEPT.

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Room 540M, 120 Wall St., New York 5, N. Y.
Room 440M, 3000 N. Going St., Portland 11, Oregon

In the United Kingdom: Imperial Chemical Industries, Ltd., Billingham, England • **In Europe:** Quaker Oats-Graanproducten N.V., Rotterdam, The Netherlands; Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France; A/S "Ota", Copenhagen, S. Denmark
In Australia: Swift & Company, Pty., Ltd., Sydney • **In Japan:** F. Kanematsu & Company Ltd., Tokyo

A Sealol HT Mechanical Pump Seal of course . . . designed expressly to end costly, dangerous stuffing box leakage in high temperature refinery process pumps. The Sealol HT Seal effectively seals hot bottoms, hot oil, and other viscous products at temperatures up to 800°F, without any external cooling circuit. The Sealol HT is a cartridge-type seal, furnished ready to install . . . no loose parts to assemble, no special machining required.

Proven in actual refinery service, this is a "hot" seal that positively eliminates shaft scoring and reduces pump seal maintenance to a minimum.

Write today for Sealol Bulletin No. 11 giving complete information on the HT Mechanical Seal . . . or submit your particular sealing problems for engineered recommendations.

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SEALOL

THE BALANCED PRESSURE SEAL

What's Happening. . .

N. Y., laboratories, and the offices in New York and Chicago. He has been concerned with the development, manufacture and application of industrial oils and greases.

T. E. Peterson has been promoted to general foreman of the Distillation department at the Humble Oil & Refining Company refinery in Baytown, Texas. He will be in charge of all crude distillation as well as certain rerun operations at Baytown. He holds a B.S. degree in chemical engineering from Texas A&M College.

Lewis L. Raymer has been named to the newly-created position of construction superintendent at Petro-Tex Chemical Corporation's butadiene plant in Houston. He formerly was superintendent of utilities at the plant.

A. H. Tomlinson, a director of Standard-Vacuum Oil Company since the firm was started in 1933, has retired after 34 years in the oil industry. For more than 20 years he was responsible for Stanvac's refining operations, all of which are in the Eastern Hemisphere.

Tomlinson joined Esso Research & Engineering Company in 1921. He became process superintendent at Esso Standard Oil Company's Bayway refinery at Linden, N. J., in 1926, and two years later went to South Sumatra as superintendent of the Sungei Gerong refinery near Palembang. Returning to the U. S. in 1932, he accepted the director's post at Stanvac's New York headquarters a year later.

Harry C. Cier has been promoted to research specialist in the Research and Development division at Humble Oil & Refining Company's Baytown, Texas, refinery. In his new position he will be active in hydrocarbon separation, with emphasis on the utilization of these techniques for the production of pure chemicals and chemical intermediates.

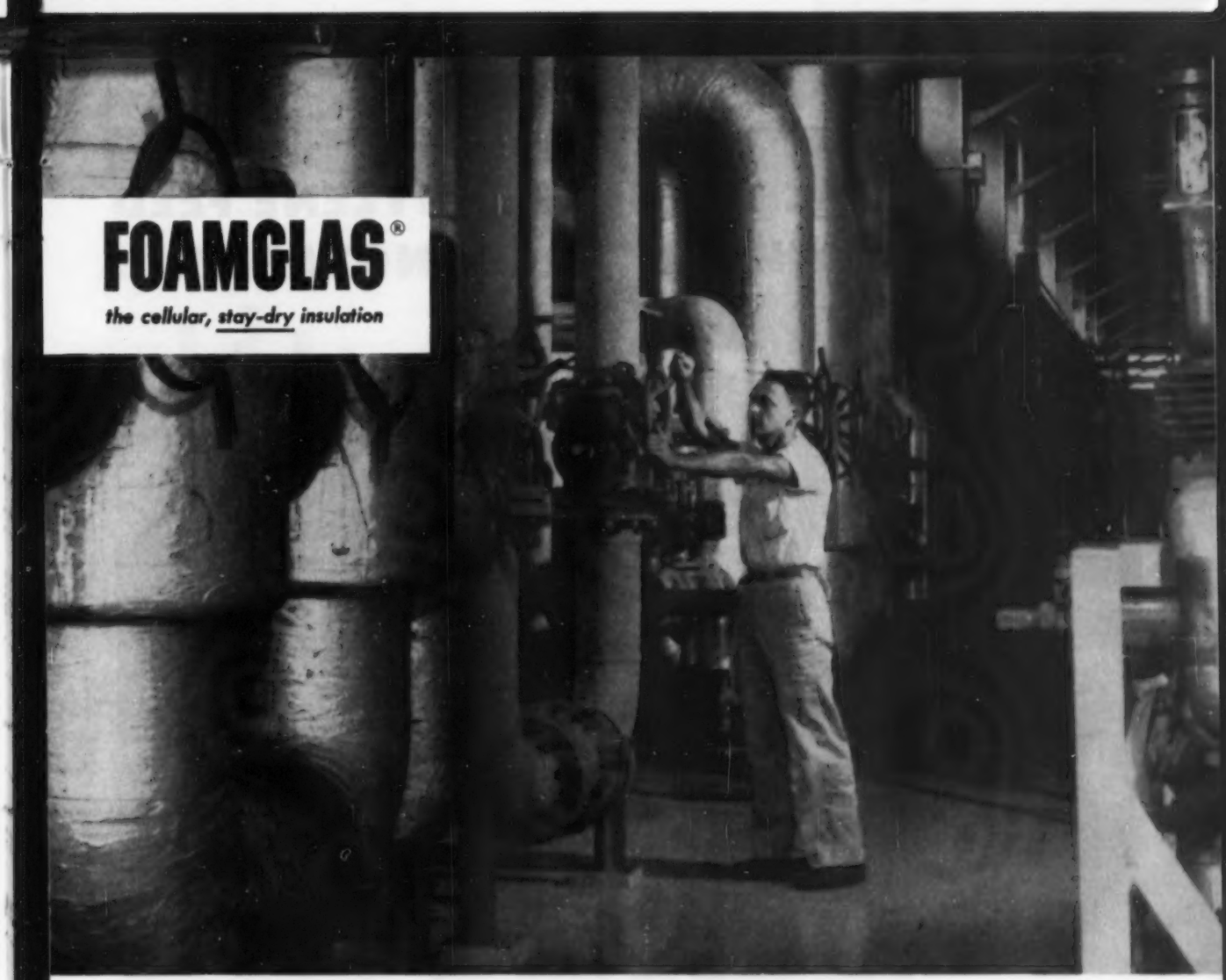
Floyd S. Bryant, appointed special assistant to the Secretary of Defense, has retired from Standard Oil Company of California as vice president and director, after 34 years with the company.

V. R. Farlow and Robert L. Grun have been transferred from their respective departments and assigned to the recently-formed Chemical Department of Gulf Oil Corporation. Farlow had been assigned to the company's Petrochemical Activities unit since 1954, and Grun had been serving as a product technologist in the Product Application section.

Douglas S. Sherwin has returned to Phillips Chemical Company as assistant coordinator for the Rubber Chemicals division, headquartered in Bartlesville, Okla. He had to be on loan to the government as secretary of the Federal Facilities Corporation, which administered the government's synthetic-rubber and tin programs.

Ralph G. McIntyre, director and for the past nine years president of Standard Oil Company, has been elected chairman

For more data on advertised products, use Readers' Service Cards, last page.



FOAMGLAS®

the cellular, stay-dry insulation

Lion Oil Co. maintains peak ammonia production because . . .

FOAMGLAS stays dry for constant insulating protection on refrigerated lines and vessels

Production of anhydrous ammonia at Lion Oil Company's Luling, Louisiana Plant requires extensive use of refrigerated lines and vessels. Precise control of temperatures (down to 12°F.) helps hold compressor suction pressure at 25 p.s.i. for peak production. Effective insulation is a must . . . but the area's prevailing high temperatures and humidities pose some tough insulating problems. FOAMGLAS solved them and gave Lion Oil these important benefits:

- The sealed glass cells of FOAMGLAS are unaffected by high humidity. That means *constant* insulating efficiency for dependable temperature control.
- Effective, *stay-dry* insulation prevents condensation on lines and vessels . . . thus cuts costly corrosion.
- Service to equipment is easily accomplished by cutting through the FOAMGLAS, then replacing only the insulation in the area immediately affected.

Recent inspection by Lion engineers showed FOAMGLAS was fully as effective as when originally applied in 1953. Maintenance has been negligible.

Whether you insulate piping, equipment or buildings, it will pay you to find out more about the *constant, long-lasting* insulating protection of FOAMGLAS. Send today for a sample and literature covering your specific needs.

Pittsburgh Corning Corporation

Dept. Z-115, One Gateway Center
Pittsburgh 22, Pennsylvania

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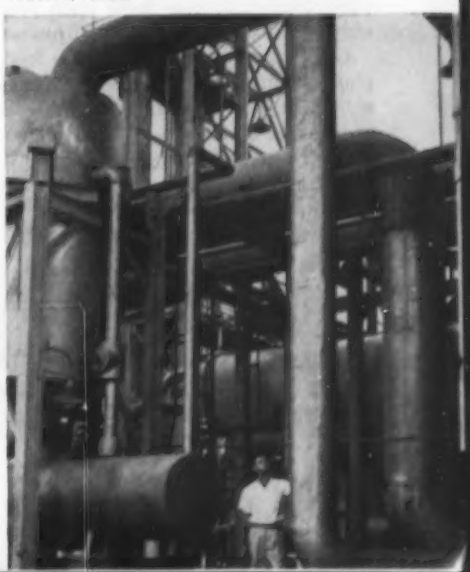
Visit our Booth No. 38 at the CHEMICAL SHOW, Philadelphia, December 5th to 9th

Light, rigid, easily shaped and fitted with available tools . . . FOAMGLAS can be swiftly and simply applied to piping and equipment of every size and shape. Insulation Contractor: B & B Engineering and Supply Company, Inc., Houston, Texas.



GULF CRACKS THREE ETHYLENE FEED STOCKS INTERCHANGEABLY...

with SELAS GRADIATION®

Gulf Oil Corporation's new ethylene plant at Port Arthur, Tex., designed and constructed by Stone & Webster Engineering Corporation. Eight Selas Gradiation heaters are in center foreground.

The world's largest ethylene-producing plant benefits from the versatility of Selas Gradiation heaters. Three separate feed stocks—propane, ethane and propane-propylene mixtures—have been processed interchangeably in all of the eight Selas furnaces.

Operating results on all three feed stocks in the Gulf plant confirm that these Selas heaters provide:

- "On stream" periods, without shutdowns, well in excess of 30 days.
- High conversions and selectivity.
- Optimum conditions, even with extreme variations in feed stock.

Zone control of heat input, enabling Selas heaters to meet any time-temperature curve in pyrolytic or catalytic reactions and high-temperature preheating, is featured by:

- Uniform heat distribution on the entire tube surface —eliminating local overheating, material degradation at the tube wall and, hence, longer tube life.
- Controlled combustion, with little or no excess air to cause external oxidation of the tubes . . . no lag in response to controller demand.

Send for copy of reprint, "Try the Gradiation Heater for Economical Ethylene Production" and Bulletin, "Gradiation Heating for Petroleum and Chemical Processing."

SELAS
CORPORATION OF AMERICA
PHILADELPHIA 34, PENNSYLVANIA

FLUID PROCESSING

SELAS

What's Happening. . .

of the board. Named to succeed him as president is K. H. Schaffer, director, vice president and assistant to the president of The California Company, a Standard Oil Company of California subsidiary. John Domercq, Jr., who has been vice president and director of Texas Standard for the past six years, resigned his position to become director, vice president and assistant to the president of The California Company.

Norman A. Shepard has retired as chemical director of American Cyanamid Company, after 42 years in the chemical industry.

Arnold L. Coldiron of Oklahoma City has been awarded the $1250 Maloney-Crawford Tank and Manufacturing Company fellowship in chemical engineering at The University of Oklahoma. Coldiron is a graduate student working on his master's degree in chemical engineering.

John B. Maerker has been named director of development at the Houdry Process Corporation Research and Development laboratories in Linwood, Pa. He succeeds **Josef W. Schall,** now assistant manager of marketing in the Chemicals division.

A licensed professional engineer, Maerker joined the corporation in 1943 as development engineer and more recently has been chief of the Commercial Development section. He will be replaced as section chief by **Frederick R. Walser,** who joined Houdry in 1952 as development engineer.

Salvatore J. Graziano has been added to the staff of Foster D. Snell, Inc., as a chemist in the Product Development department, and **Walter A. Bilz** has joined the department as a junior chemist. Also receiving a new appointment was **Richard J. Davidson,** assigned to the Product Evaluation department as a chemist.

Deaths

William Keen, who retired last year as manager of domestic marketing operations for The Atlantic Refining Company, died August 26 at Bryn Mawr, Pa. He was 63 years old.

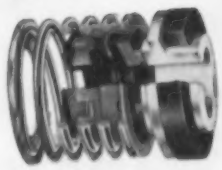
D. B. O'Neill, executive vice president of the Independent Refiners' Association of California, died recently in Santa Monica, Calif. He was 62-years-old. Death was attributed to a heart attack. O'Neill had been with the association since 1936.

George Waltershausen, retired general superintendent of Deep Rock Oil Company's Cushing, Okla., refinery, died October 15.

Aaron B. Bagsar, retired chief metallurgical engineer for Sun Oil Company, died October 7. He was 58-years-old. Dr. Aaron had been with the Sun organization 22 years. During World War II he was a member of a War Production Board subcommittee and served on a welding research committee for the National Academy of Sciences.

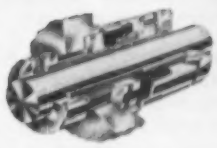
3 JOHN CRANE Shaft SEALS
for lifetime performance in any petroleum or petrochemical service

TYPES 1 and 2
Synthetic Rubber Bellows • For Low Pressure Service



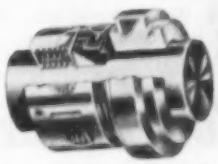
Services: gasoline, diesel fuel, fuel oil, crude oil, butane, propane, ethane and similar products non-injurious to synthetic rubber.
Pressures: to 200 psi.
Temperatures: −40°F to +212°F.
Construction Data: Factory assembled. Self-adjusting sealing head. Lapped faces positively prevent leakage. Low spring pressure for minimum wear. *Available in balanced construction for pressures to 550 psi.*

TYPE 8B
Packaged Type Seal • For High Pressure Service



Services: Same as Types 1 and 2.
Pressures: to 1200 psi.
Temperatures: −40°F to +250°F.
Construction Data: Heavy duty. Hydraulically balanced to handle high pressures. Single-unit package for easy installation.

TYPE 9
Sealing Members Made of Teflon* • Engineered for service conditions that do not permit use of rubber



Services: alkyl benzine, benzine, creosote, silicone oil, some petroleum derivatives, and all known corrosives.
Pressures: to 150 psi. (balanced construction to 750 psi.)
Temperatures: −120°F. to +500°F.
Construction Data: Furnished in the metallurgical specification best suited to the particular service. Flexible wedge ring and sealing ring molded from chemically inert Teflon.

Contact "John Crane" for the shaft seal best suited to your requirements. Request bulletin giving full information on "John Crane's" complete line of mechanical seals.

Crane Packing Co., 1820 Cuyler Ave., Chicago 13, Ill.
In Canada: Crane Packing Co., Ltd., 617 Parkdale Ave., N., Hamilton, Ont.
*DuPont trademark

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

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has the answer to

CORROSION

with

1. Holcombe Selenium Rectifiers
2. Lion Asphalt Pipe Coatings
3. Fiberglas & Asbestos Wraps
4. Graphite Anodes
5. Coke Breeze

Counteracting corrosion of underground pipes can mean tremendous savings for your company. As part of its famous "one for all" service, ToPaz distributes the complete Holcombe Company line of pipeline protection equipment and supplies.

You can trust ToPaz for high quality, dependable corrosion prevention equipment at all times. Contact ToPaz for all pipeline equipment and supplies. You can depend on ToPaz for fast delivery and prompt, personal attention to your order. You'll get the job done faster with ToPaz helping you.

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Heard at Meetings . . .

Fighting Pollution*. . .

One method of nipping air and stream pollution in the bud is to consider the prevention of pollution in the initial stages of design of the plant. (Dr. W. A. Quebedeaus, Jr., Harris County Health Unit, Houston.)

Dispose of undesirable byproduct wastes may be handled by pumping them underground into disposal wells. The disposed waste product must be treated to make it compatible with the natural fluids in the disposal sand. (H. O. Henkel, Du Pont Company, Victoria, Texas.)

Checking the growth and wellbeing of micro-organisms in our streams is one method of determining their health. (Miss Ruth Pactrick's paper of the Academy of Natural Sciences of Philadelphia was read at the meeting.)

You can actually stop pollution of the air if you make process changes, refining changes and use different methods of recovering treating byproducts. (A. R. Dudley, Humble Oil and Refining Company, Baytown, Texas.)

Petrochemicals and Fibers*

With cotton consumption down slightly, the use of petrochemicals to treat and modify this natural fiber will expand and amplify the use of both. Already considerable use is being made of polyvinyl alcohols and acetates, urea, melamine and other formaldehyde resins for stiffening agents in competition with starch. Fiber modifications are made with the use of acetic anhydride and acrylonitrile which improves rot and mildew resistance as well as heat resistance (Gilbert E. Goheen, U. S. Department of Agriculture, New Orleans).

Symposium and Corrosion†

Process Industries; Oil and Gas Production; Protective Coating; Utilities; Marine Corrosion; Corrosion and Inhibitor; Cathodic Protection; High-Temperature Corrosion. These are the topics covered in symposia with leaders in the field presiding.

* AIChE, Galveston, Texas.
† NACE, Houston.

Which Cooling Medium?*

When water at a natural gasoline plant site is plentiful and of good quality, there is no question that water cooling is perferable to air cooling. When this is not the case, a detailed economic study will be needed before a decision can be reached on air versus water. In West Texas installations, where no water is available, the plants have had to go to air cooling, with refrigeration (Joe Weatherby, Stearns-Rogers Manufacturing Company, Denver).

Design Codes*. . .

The popularity of codes as a factor in plant design will continue. Though many codes are available to date, they are becoming simpler and more unified. For example the ASME code for Unfired Pressure Vessels is becoming more parallel to the API-ASME code for Unfired Pressure Vessels. The result will be one code instead of two (Clyde Youn, Dresser Engineering Company, Tulsa).

Don't Wreck It*. . .

Even neglect downtime, the cost of corrosion inspection can be cut 10 to 25 percent by the use of non-destructive testing. Most of the instruments available for such testing today are ultrasonic. For most natural-gasoline plant testing, the use of these instruments does not require intensive training (Dwight Evans, Engineering Test Service, Tulsa).

Corrosion Mechanism*. . .

There is no substitute for a fundamental understanding of the corrosion mechanism when trying to control corrosion damage. Cathodic protection of pipe lines has become so popular that this form of corrosion protection has been extended to tank bottoms with success (C. O. Smith, The Carter Oil Company, Tulsa).

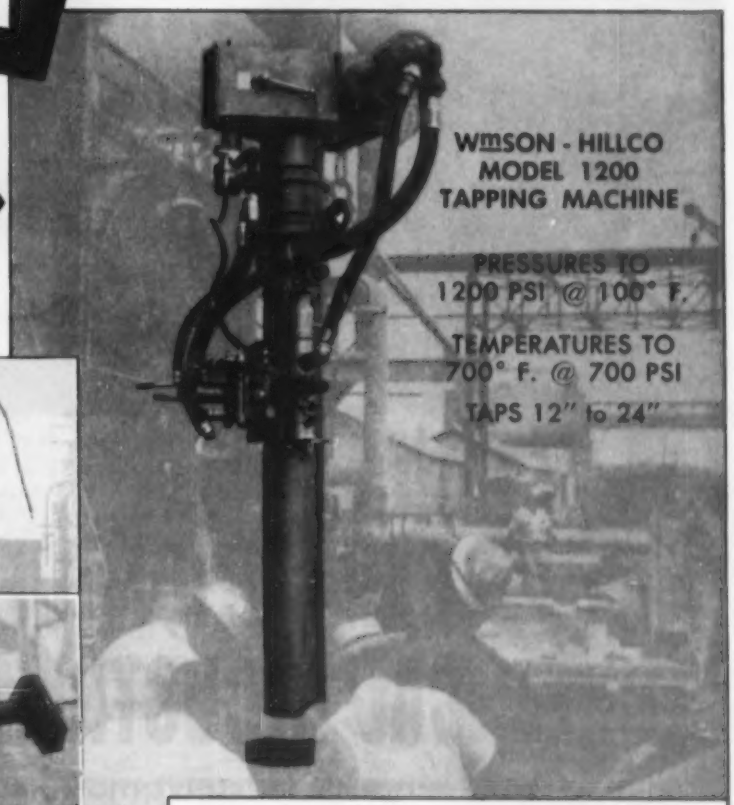
100-Octane in Every Pump†

When 100-octane gasoline is available from every service-station pump, gasolines will be made from blending

* Oklahoma NGAA.
† California, NGAA, Los Angeles.

THE BIG 4 ...in High Pressure-High Temperature TAPPING MACHINES

LARGE GULF COAST REFINERY MAKES 20" TAP INTO 24" STEAM LINE AT 600°F. AND 200 PSI PRESSURE . . . WITHOUT SHUTDOWN.



WmSON - HILLCO MODEL 1200 TAPPING MACHINE

PRESSURES TO 1200 PSI @ 100° F.

TEMPERATURES TO 700° F. @ 700 PSI

TAPS 12" to 24"

MODEL 660
TAPS 3" TO 14"

MODEL 300
TAPS 4" & SMALLER

MODEL 100
TAPS 2" & SMALLER

MANY REFINERIES SUCH AS THE ONE SHOWN ABOVE HAVE PROVED WmSON-HILLCO TAPPING MACHINES FOR MAKING CONNECTIONS TO:

- HIGH TEMPERATURE STEAM LINES
- HIGH PRESSURE GASOLINE AND UTILITY LINES
- CEMENT LINED AND TRANSITE PIPE
- PRESSURE VESSELS

Rental-purchase option applicable to models 1200 and 660.

WRITE FOR LITERATURE

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For more data on advertised products, use Readers' Service Cards, last page.

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25th EXPOSITION OF CHEMICAL INDUSTRIES

COMMERCIAL MUSEUM AND CONVENTION HALL

Philadelphia Dec. 5-9

Developments in the chemical process industries are rapid. What was new yesterday may be obsolete today. But you can keep up with new techniques, ideas, processes, methods, materials and equipment in an easy, time-saving way . . . by attending this great exposition with its over 500 fact-filled exhibits! *Just one idea you pick up here may profit you over and over again!*

SEE and **COMPARE**, first-hand, the new materials and processing methods that others are using—**LEARN** how they may be applied to your operations . . . **TALK** with top-notch technical personnel about the latest in equipment and materials . . . **KEEP ABREAST** of the trends that may affect your business tomorrow!

Don't miss this great opportunity! Save time by writing now for free advance registration and forms for hotel accommodations to

MANAGEMENT: INTERNATIONAL EXPOSITION COMPANY
480 Lexington Avenue, New York 17, N. Y.

Who's Meeting . . .

practically pure chemicals. Ethyl Corporation has been studying how these superfuels can be produced most economically, and researchers have prepared and engine-tested many blends of the four basic types of chemicals—olefins, paraffins, naphthenes and aromatics—present in gasoline stocks. Results show how varying proportions of these components can be blended with tetraethyl lead to form the most effective gasoline.

Ethyl's studies show that the best over-all anti-knock performance can be obtained by blending a high proportion of aromatic stock with paraffinic stock and adding the maximum of TEL. High aromatic content gives optimum low-speed knock resistance. Where high-speed anti-knock performance is critical, high aromatic content is less important, but maximum TEL concentration is still essential.

At refineries where only the olefinic and paraffinic types of stock are available, highly-paraffinic blends will give the best obtainable over-all performance, provided they contain the maximum concentration of TEL.

At such time that gasoline blending becomes a matter of fitting together essentially pure hydrocarbon types behaviour data obtained in programs of this type may constitute a guide for optimum use of components (F. D. Buerstetta and T. W. Warren, Ethyl Corporation, Detroit).

In the Future

Advances in technology, materials and methods will awaken worldwide interest in the 25th Exposition of Chemical Industries at Philadelphia, December 5-9, 1955. Displays of chemical substances, chemical manufactures, and manufacturing equipment will tax the capacity of the Commercial Museum and Convention Hall. The exposition will be one of the largest events of this kind ever assembled under one roof. The novelty and wide reaching influence of the innovations to be seen however, will be even more impressive than the expanse of exhibits.

Chemical methods of manufacture, that is, processing through the interaction of different substances, have more in common with the better

understood mechanical manufacturing processes than is generally appreciated. One reforms the molecules, the other alters the physical character of materials; yet both employ many of the same methods. The exposition will embrace a comprehensive showing of mechanical as well as chemical engineering and will be of universal manufacturing interest.

MEETINGS CALENDAR

NOV.	
13–18	Society of Mechanical Engineers, (75th Anniversary Meeting), Blackstone and Hilton Hotels, Chicago.
14	Natural Association of Corrosion Engineers (Western Regional Division), Three-day Short Course on Corrosion problems, University of California, San Francisco.
14–15	Commercial Chemical Development Association and Chemical Market Research Association (Joint Meeting), Carter Hotel, Cleveland.
14–17	American Petroleum Institute (Annual Meeting), Mark Hopkins, Fairmont, St. Francis and Palace Hotels, San Francisco.
14–17	International Automation Exposition, Chicago Navy Pier, Chicago.
14–18	Chicago Exposition of Power and Mechanical Engineering, Sponsored by The American Society of Mechanical Engineers, Chicago Coliseum, Chicago.
15–16	American Petroleum Institute (Board of Directors Meeting), Mark Hopkins Hotel, San Francisco.
16	Oil Industry Information Committee (Steering Committee Meeting), St. Francis Hotel, San Francisco.
16	American Petroleum Institute (Executive Committee Meeting), Mark Hopkins Hotel, San Francisco.
18–22	National Safety Council and National Safety Congress and Exposition, Chicago.
20	National Petroleum Council, South Interior Building, Washington.
20–21	Western Petroleum Refiners Association (Regional Meeting and Industrial Relations Meeting), Garrett Hotel, El Dorado, Ark.
27–30	American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, Detroit.
DEC.	
1–3	American Chemical Society (Southwest Meeting), Shamrock Hilton Hotel, Houston.
2	Natural Gasoline Association of America (Regional Meeting), Herring Hotel, Amarillo, Texas.
5– 9	Exposition of Chemical Industries, Commercial Museum and Convention Hall, Philadelphia.
8– 9	American Petroleum Institute, Oil Industry Information Committee, Biltmore Hotel, New York.
JAN.	
19–20	National Industrial Conference Board, Commodore Hotel, New York.
23–26	Plant Maintenance and Engineering Show, Convention Hall, Philadelphia.
25–26	Northwest Petroleum Association (Annual Convention), Nicollette Hotel, Minneapolis, Minn.
25–27	Instrumentation for the Process Industries Symposium, Sponsored by the Chemical Engineering Department, Texas A&M College, College Station, Texas.
26–27	Plan Maintenance and Engineering Conference, Warwick Hotel, Philadelphia.
30 Feb. 3	American Institute of Electrical Engineers (General Meeting), Hotel Statler, New York.
FEB.	
24	Natural Gasoline Association of America (Regional Meeting), Lincoln Hotel, Odessa, Texas.
27 Mar. 2	American Society for Testing Materials (Committee Week), Statler Hotel, Buffalo, New York.

Who's Meeting . . .

The purpose of the exposition is to aquaint chemists, engineers and industrial managements with the latest developments in chemical substances, products of chemical processing, and processing equipment, also instruments and equipment employed in research and development. The exposition is not a trade show in the accepted sense, but an exhibition of typical materials and equipment which provides a forum for discussion of technical problems. As much of the equipment used in manufacturing is built to specifications as a part of the design of individual plants, the exposition will be a planner's show.

The field covered by the exposition comprises the production of chemicals, the entire range of chemical processing and the use of chemical ingredients in many mechanical processes. Chemistry is no mere "test tube" industry. It is a manufacturing industry of great magnitude. Its production in foodstuffs, petroleum prod-

ROBINSON OLDEST NAME IN ORIFICE FITTINGS

Type E For Low Pressure . . .

2" to 30" A.G.A. Spec.

Where, except at Robinson, can you obtain all these features in an orifice fitting for gas or liquid flow? Extreme accuracy of measurement is yours because the Robinson orifice is always centered with the piping and sealed against leakage. Orifice plates can be changed safely and quickly (3 to 5 minutes) with no interruption in flow, no hazards or gas loss. Various sizes and pressure ranges up to 3,600 PSI, flanged or welding neck.

Type E For High Pressure . . .

2" to 6" Pipe Size A.G.A. Spec.

Same fine metering characteristics as the standard low pressure Type E shown above, but built for 6,000 PSI with positive pressure seal which becomes tighter as the pressure increases. Safety is assured because the fitting cannot be opened until the pressure is released. Available in flanged or welding neck. Compare Robinson point-by-point and you'll choose Robinson.

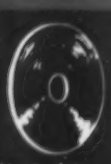
SEND FOR ROBINSON CATALOG NO. 54.

ROBINSON ORIFICE FITTING COMPANY

2830 LUGO STREET • LOS ANGELES 23, CALIF.

ORIFICE PLATES AND HOLDERS

Standardize on Robinson orifice plates regardless of the make of fittings on your lines. Robinson plates conform rigidly to A.G.A. requirements. Our 30 year reputation for building accurate orifice plates is protection you can count upon.



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TUBING

UP TO

58 FEET LONG

FOR

CONDENSERS

and **HEAT**

EXCHANGERS

Now you can get STRAIGHT lengths up to 58 feet long...at Pacific Tube

Pacific Tube Company has added new pickling facilities, new hydrostatic testing equipment...with the longest draw bench in the west to quantity-produce for you, straight lengths of Seamless Tubing up to 58 feet long. Pacific Seamless Steel Tubing is "Quality Controlled" to insure workability, accurate bending, flarability and long life. It is precision drawn to meet critical specifications and tolerances.

Pacific Tube Company is strategically located to serve you efficiently, economically & promptly.

If you have a tubing problem, ask the Pacific experts for help...you'll be glad you did.

Pacific TUBE COMPANY

Manufacturers of

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Our movie...
"Steel Tubes for Industry"
available without charge.

Who's Meeting . . .

ucts, textiles, plastics, medicines, and many others is enormous.

75 Years for ASME

The theme of this year's meeting of the 40,000-member American Society of Mechanical Engineers will be "The Engineer and the World of Commerce and Industry." The society's annual meeting will be held November 13-18 in Chicago.

Of the 350 technical papers to be presented at more than 100 sessions, some will be in the following fields: boiler feedwater studies, consulting engineering, fluid meters, fuels, gas-turbine power, heat transfer, high-temperature steam generation, hydraulics, instruments and regulators, management, materials handling, mechanical-pressure elements, nuclear engineering, oil and gas power, petroleum, process industries, production engineering, rubber and plastics, and safety.

A highlight of the meeting will be a dinner and pageant depicting milestones in ASME history from its founding in 1880 to the present. The presentation is being arranged by the Society's Chicago section.

Concurrently with the meeting, ASME is sponsoring the Exposition of Power and Mechanical Engineering at Chicago Coliseum November 14-18.

Tomorrow's Motor Fuels*

The trend toward higher-powered automobiles will demand more from tomorrow's fuels. The greater horsepower probably will come from higher compression ratios so as not to increase the size of power plants. It is expected that by 1960 the compression ratio will be 9:1 with a maximum for some makes of 10:1. It is predicted that a 95-octane fuel will satisfy 50 percent of all 1960 model cars. A 99.7-octane fuel will be required to satisfy 95 percent of these cars with some of the models requiring 100 octane fuel for 95-percent satisfaction. The higher-octane fuels will come from a wider use of lead addition, alkylation, and isomerization. (R. D. Diggs, E. I. du Pont de Nemours and Company, Wilmington, Del.)

* California NGAA, Los Angeles.

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TYPE OJ
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Stage Centrifugal Pump
For general water supply for municipalities, industries, office buildings, institutions—also—for handling liquids, chemical solutions, oils etc., in a wide variety of industries. Write for Bulletin 105-BM for further details.
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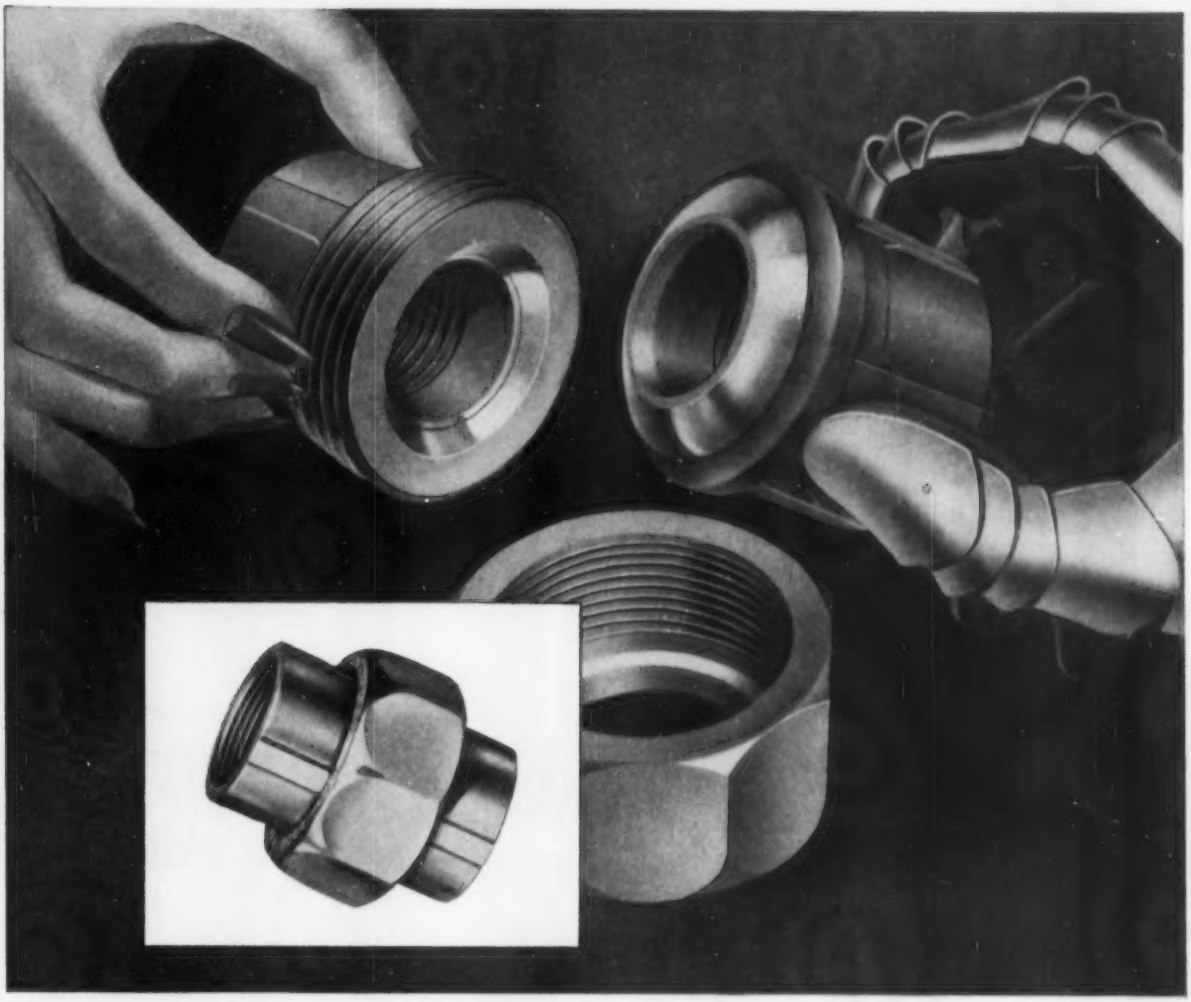


What a *difference* 150 Brinell makes!

Here's what makes the big difference! *The male seat of the new Rockwood Union #603 is specially treated to make it 150 Brinell harder than the female seat.* That means no galling in make up — longer life for the joint.

This hardness differential gives you superior performance — even under tough working conditions. Each part of the Rockwood Union #603 is interchangeable. Both seats are made of corrosion-resistant AISI molychrome steel, forged in place and bonded-locked under 100,000 and 400,000 pound pressure.

But the difference doesn't stop there! Exclusive "Rockwoodizing" protects entire Union, including threads, against corrosion.

This remarkable Union offers you all these features. You can't ask for anything better.

For complete facts, mail coupon now.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all Principal Industrial Areas

ROCKWOOD SPRINKLER COMPANY
939 Harlow Street
Worcester 5, Massachusetts

Please send me prices and further data on the new Rockwood Union #603. I would also like the name of the nearest Rockwood distributor.

Name.....

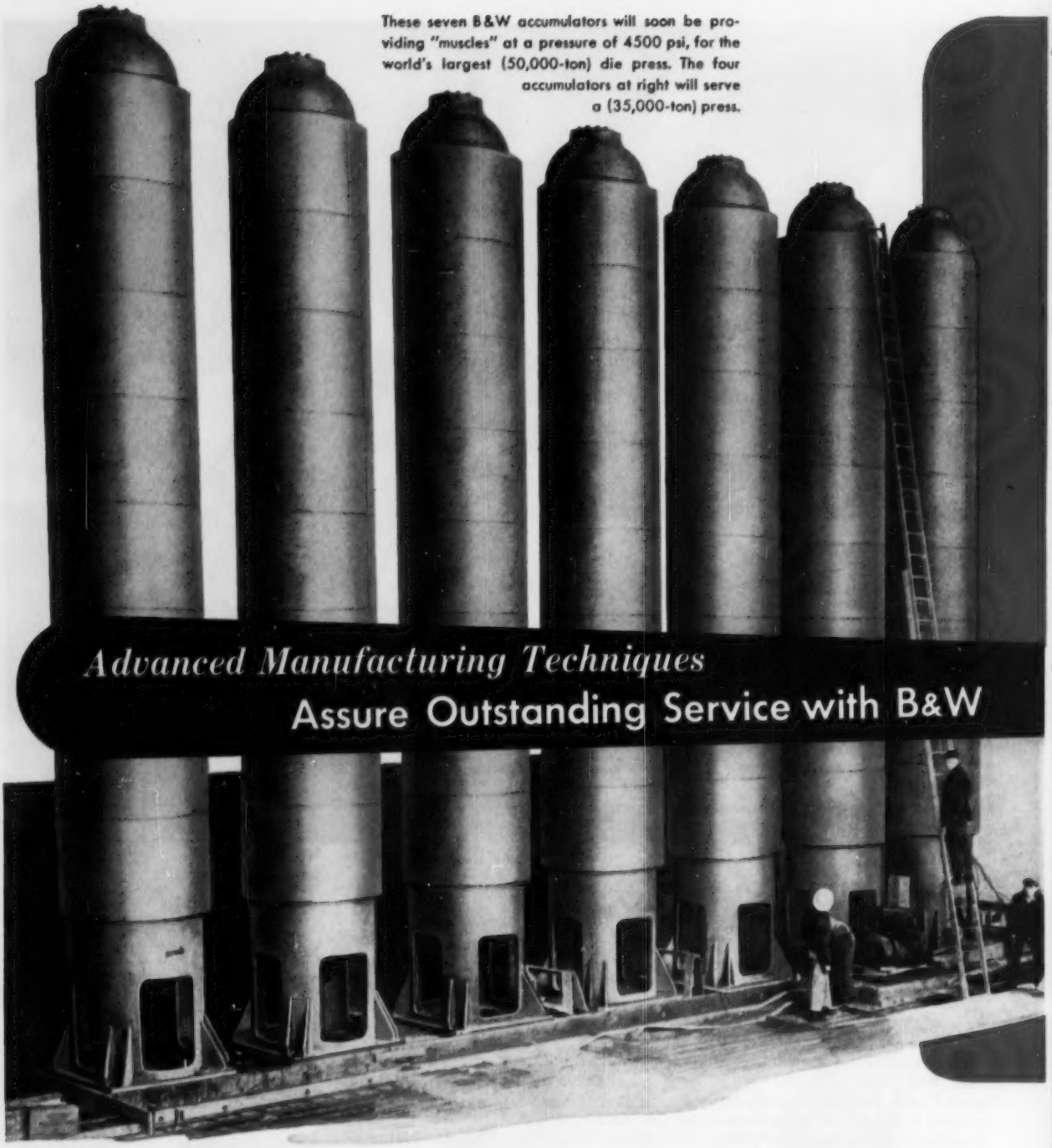
Title.....

Company.....

City.....

Zone.....State.....

For more data on advertised products, use Readers' Service Cards, last page.



These seven B&W accumulators will soon be providing "muscles" at a pressure of 4500 psi, for the world's largest (50,000-ton) die press. The four accumulators at right will serve a (35,000-ton) press.

Advanced Manufacturing Techniques
Assure Outstanding Service with B&W

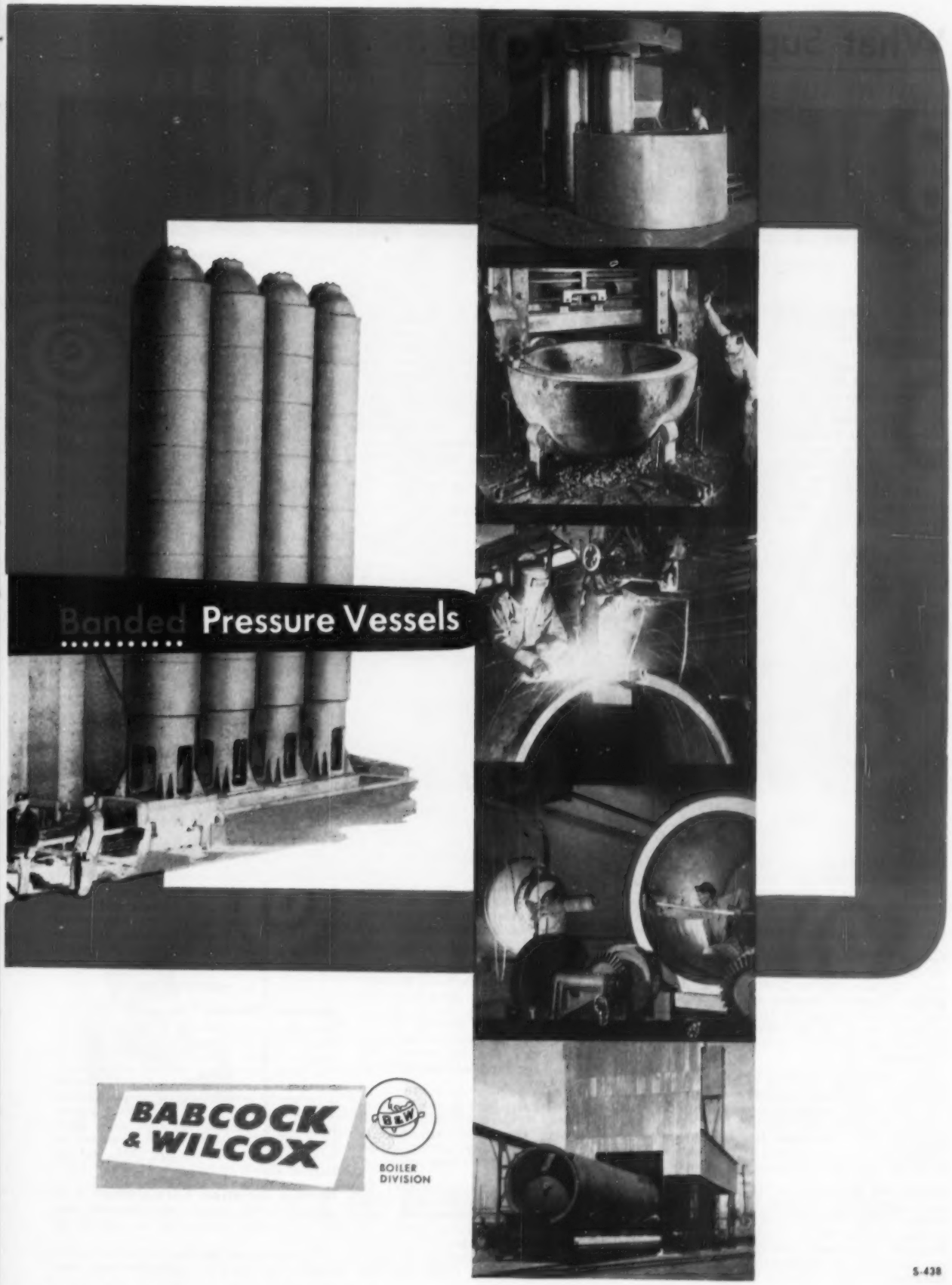
Every step in the manufacture of B&W banded pressure vessels is a specialized operation derived from long experience in meeting extraordinary needs.

The inner shell is fabricated to withstand longitudinal pressure loading in accordance with ASME Code requirements. Circumferential reinforcing bands around this inner shell enable it to withstand circumferential pressure loading while affording maximum protection.

Much of the equipment used in each manufacturing step was specially designed and developed by B&W, whose forming, machining, welding, stress relieving and inspection are much more specialized techniques than their names indicate.

The result? Pressure vessels designed for 2000 to over 6000 psi, with capacities from 50 to 10,000 gallons, and the ultimate in safe and sound process equipment with greater "all-around" advantages than vessels of conventional welded construction. Whatever your pressure vessel requirements, you will do well to consult The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

For more data on advertised products, use Readers' Service Cards, last page.



BABCOCK & WILCOX

BOILER DIVISION

S-438

What Suppliers Are Doing . . .

Morgan | Fitzgerald | Watts | Morse | Horn | Young | Harris | Jennings | Felix

Donald C. Morgan, Chicago district sales manager for **Rockwell Manufacturing Company's** Meter and Valve division, has been named Central regional sales manager with offices in Pittsburgh. With the company since 1930, Morgan replaces **Carl C. Moore**, who retired.

J. N. Fitzgerald, a vice president with **Warner Lewis Company** since 1948, has been named to replace **Warner Lewis** as president of the company. Lewis was promoted to chairman of the board. Fitzgerald, who has been stationed in the Washington, D. C., offices of the affiliated Fram Corporation, will headquarter in Tulsa.

Lee Watts heads a San Francisco office recently opened by **Pacific Pumps, Inc.**, to handle centrifugal-pump sales. Watts formerly was associated with the company's district office in Los Angeles.

Arthur B. Morse is the new vice president and western sales manager of **Mexico Refractories Company.** For the past five years, he has been the company's California district manager. He previously was a vice president of Laclede-Christy Co.

L. D. Horn, retired fire inspector for the Los Angeles Fire department, is handling fire-fighting equipment for **The Republic Supply Company of California.** A former prize fighter, Horn fought Max Schmeling in Germany before he quit the ring in 1927 to join the fire department.

Robert P. Young has been named manager of the New York district office of **Peerless Pump Division**, Food Machinery and Chemical Corporation. He succeeds F. W. McCann, who resigned. Young joined the company in 1948, and more recently had been sales engineer with headquarters in Pittsburgh.

William H. Harris has been made assistant to the vice president in charge of manufacturing sales for **Scovill Manufacturing Company.** He formerly was sales manager of aircraft fasteners in the Contract Manufacturing division.

Edward F. Jennings has been appointed New York district sales manager for **Laclede-Christy Company Division**, H. K. Porter Company, Inc. In addition to his new duties, he will continue to supervise Export Sales. Jennings has been with the company since 1934, in various sales capacities, and has been handling export sales since 1951.

Samuel P. Felix, general manager of **De Laval Turbine Pacific Company**, has been elevated to vice president. In addition to his new responsibilities as a vice president, he will continue to serve as general manager.

Davis | Holton | Sheen | Robertson | Mackie | Van Loozen | Dietz | Huff | Walters

Peter B. Davies has been appointed assistant sales manager of **Philadelphia Gear Works.** This is a new position with the company, created to handle sales administration. Davies has been a sales engineer with the company since 1948.

George V. Holton, formerly chairman of the board of Socony Mobil Oil Company, Inc., has been elected a director of **The Perkin-Elmer Corporation.** He served as a vice president of Socony Mobil from 1938 to 1948, when he was elected chairman. He held that position until his retirement earlier this year.

Robert T. Sheen, president of **Milton Roy Company**, has been elected president of the Instrument Society of America. Sheen joined his father in founding the company in 1937. He also has been with Monsanto Chemical Company and served W. H. & L. D. Betz as consulting engineer.

William M. Robertson has been appointed sales representative in New York, for **Wolverine Tube**, Division of Calumet & Hecla, Inc. He will be replacing William Bothwell. Robertson was formerly sales representative of Wolverine Tube in Rochester, N. Y.

W. C. Mackie has been appointed technical sales representative on the Pacific Coast for **Rhodia, Inc.** He has established temporary headquarters in Pasadena, Calif. Mackie will supervise both sales and engineering in industrial odor control and abatement.

C. F. Van Loozen has joined **Macco Corporation** with an assignment to its Refinery and Construction division sales force. He previously was with the Ideco Dresser Equipment Company ten years in its Domestic and Export sales and as California sales manager. He also has served with The Lummus Company and with Oil Well Supply Company.

Robert L. Dietz has been named to manage **The Claud S. Gordon Company's** district office in Cincinnati. He recently joined the company after serving in the sales force of Radio Corporation of America.

H. A. Huff, Jr., welding specialist with **Air Reduction Sales Company**, has been made regional process representative for the company's Magnolia (southwest) region. He will headquarter in Houston. With the company since 1942, Huff has been connected with the welding industry over 30 years.

John G. Walters has been selected to represent **Infilco, Inc.**, in Georgia and North and South Carolina. Walters, who served the Maryland Water Pollution Commission as its first field representative, joined Infilco in 1953.

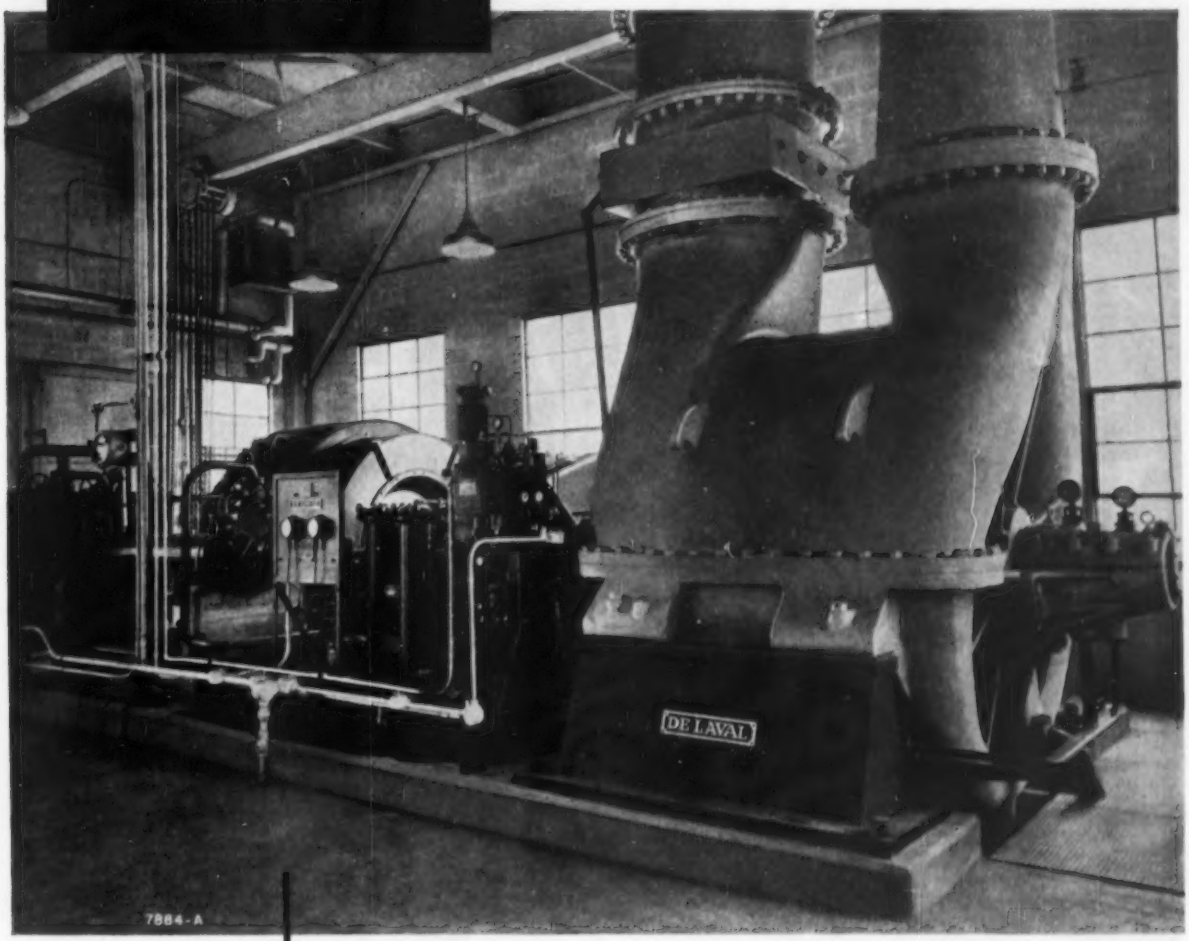
General Electric Company will start pilot-plant operations at a new multi-million dollar plant near Roanoke, Va. The plant of more than 600,000 square feet will house manufacturing and office facilities for the company's Industry Control department which now is headquartered in Schenectady, N. Y. Transfer of operations from Schenectady will take place gradually. The new plant is expected to be completed about January 1956, and the transfer should be completed early in 1957.

Bendix Aviation Corporation will complete a $2 million expansion program of its Scintilla division by the end of the year.

The divisional program is part of a $10 million expansion of corporation engineer-

DE LAVAL CENTRIFUGAL BLOWER

supplies 48,400 cfm for new British American cat cracker



Send for new Bulletin 0504

This De Laval centrifugal blower does a dependable job in the new Model B Orthoflow cat cracker of the British American Oil Co., Ltd. at Clarkson, Ontario.

The unit delivers 48,400 cubic feet of air per minute for the regeneration of spent catalyst. Inlet pressure is 14.2 psia, and discharge pressure 35.4 psia. The De Laval blower operating at 3,700 rpm is driven through a speed increasing gear by a 4,500 hp electric motor.

De Laval blowers are designed and built for heavy duty continuous operation. Rugged, horizontally split casings, individually designed impellers, perfectly balanced rotors and externally mounted, cylindrically seated bearings are design features that assure optimum performance and long service.

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

811 Nottingham Way, Trenton 2, New Jersey

DL507

Suppliers . . .

ing facilities announced earlier this year. New facilities now under construction cover 25,000 square feet and will be devoted to manufacturing as well as research on many types of electrical equipment, including ignition systems, magnetos, diesel fuel injection systems, and electrical connectors.

Chemical Process Company now has **Charles H. O'Connell** as its district manager at Pauls Valley, Okla. He formerly was assistant district manager at the company's Seminole, Okla., station. O'Connell joined the company in 1948.

Chiksan Company recently concluded its second general sales conference at the main plant and home office at Brea, Calif. Attending the three-day session more than 70 salesmen and representatives from throughout the U. S., Canada, and South America.

Chicago Bridge & Iron Company has made three new personnel changes in its sales organization. Robert S. Chamberlain has joined the company's San Francisco sales office, transferring from the general sales office in Chicago, and Arthur G. Albertson, with the company since 1952, has been assigned to the Los Angeles office. Julius D. Holmquist has joined the sales office at Philadelphia. He had been stationed at Greenville, Pa.

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wherever there is gas
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'Dry-Air GAS
GRAVITOMETERS
This new Arcco-Anubis Dry Air Gas Gravitometer determines and records specific gravity of gases automatically corrected to the humidity content of the air. The difference in weight between a column of GAS and equal column of DRY AIR is measured. This ratio represents the true specific gravity of the sample.
One bell of the instrument is filled with gas which is being measured, and the other bell is filled with dry air. Otherwise, except for the new instrument having one column for gas and one column for dry air, the unit is identical in operation to the standard gas gravitometer. When calibrated and properly installed, these instruments require little attention other than to wind the clock, ink the pen, and change the chart. Send for bulletin No. 101.
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RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
Available for Early Delivery
Send for Bulletin 101

Joy Manufacturing Company has appointed **J. E. Douglass** as district sales manager for the company's El Paso, Texas, territory. He succeeds **E. E. Miller,** who retired after 43 years with the company, several of which were spent overseas with the Export department.

Earlier this year, Douglass was appointed assistant district manager at El Paso. He joined the Joy organization in 1945 and was assigned to the Birmingham-Knoxville territory. In 1950, he was transferred to the Phoenix, Ariz., area of the El Paso district as sales engineer.

Ethyl Corporation has elected **Lawrence R. Hafstad** to its board of directors. He is a vice president of General Motors Corporation and director of the General Motors research staff. Hafstad succeeds Charles L. McCuen who retired as an Ethyl director, vice president of General Motors and general manager of its Research Laboratories division.

Hafstad

Dr. Hafstad was a physicist for Carnegie Institute from 1927 to 1945, later served as director of research for the Applied Physics laboratory at Johns Hopkins University, and was a director of the Atomic Energy division of Chas Manhattan.

In 1947 he was named executive secretary of the Research and Development board in the office of the Secretary of Defense. He continued in this assignment until 1949 when he was appointed the first director of the Reactor Development division of the AEC.

Cummins Engine Company, Inc., has set up a new distributorship to handle its diesel products in Alaska. The new unit, to be known as Cummins Diesel Sales of Alaska, Inc., will be headed by **R. B. Newell,** formerly vice president of the company's sales organization in Seattle. He was named president of the new Alaska branch. It will be headquartered in Anchorage.

Shippers' Car Line Corporation, a subsidiary of ACF Industries, Inc., has appointed **Thomas J. Rowe** as vice president. Rowe joined ACF Industries in 1953, and later that year was made resident comptroller of Shippers' Car Line Corporation. Prior to this he had been with National Broadcasting Company and on the faculty of Rutgers University.

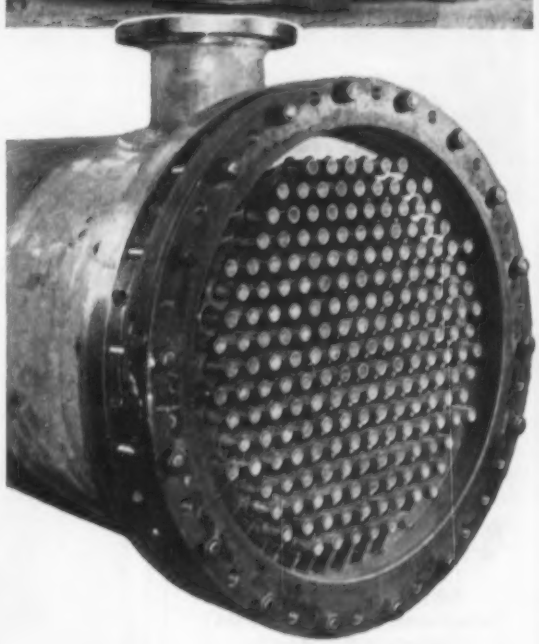
U. S. Steel Corporation has made **Griswold A. Price** assistant vice president in charge of sales for its Western area. He succeeds **Herbert J. Watt,** who is retiring after 43 years as a sales executive in the steel industry.

Price, who has spent his entire working career with U. S. Steel, joined the company in 1919 at its Gary, Ind., steel works. He had been manager of the Chicago district office since 1947.

L. O. F. Glass Fibers Company has named **Chester E. Shepperly** as district manager for its Boston area. He will headquarter in a new office at Newtonville, Mass., in the company's Eastern Regional Sales area. Shepperly previously was district manager in that area for Fiber Glass

"Pack Off Your Troubles..."

SPENCER®



THE PROBLEM: One of Spencer Chemical Company's plants needed an air preheater to handle nitrogen gases at 1600°F. on the tube side, against air at 330°F. on the shell side. These widely different temperatures produced a 2" differential expansion between tubes and shell.

ENGINEERING: Western heat transfer engineers considered several possible solutions: a) An expansion joint in the shell; b) Individual tube packing; c) A packing gland in the shell.

CONSULTATION: These approaches were discussed with the Spencer engineers. After mutual examination of plant design problems, the individual tube packing method was chosen. Upon completion of the precision fitting and welding there was adequate room for expansion and contraction of the tubes within their individual packing glands.

IMPORTANCE: The Spencer Chemical Company job typifies Western's capabilities in working *with* the client to satisfactorily solve the specialized engineering and fabricating problems of today's high temperature, high pressure services.

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HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
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130 Casa Linda Plaza, Dallas 18, Texas
PROCESS INSTRUMENTS & EQUIP. CO. - North Bldg., Charleston, W. Va.
H. W. SEVERANCE—Marion E. Taylor Bldg., Louisville, Ky.

For more data on advertised products, use Readers' Service Cards, last page.

ERNST

SIGHT FLOW INDICATORS

"See What Goes On Inside"

For insertion into pipe

FOR EVERY APPLICATION

BRONZE, IRON, STEEL, STAINLESS STEEL

FIG. 29
Cylinder with Impeller

FIG. 17-28
Cylinder

FIG. 215
Flanged

FIG. E-57
Double Window

FIG. 212
Visibility Welding Neck or Screw

FIG. E-811
Flapper

FIG. E-1810
Rotating Wheel Type

All sizes up to 6" *Send for Catalog*

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LIVINGSTON, N. J.

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GULF COAST'S
Foremost Metallizers

TURBINE SHAFTS
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PUMP SLEEVES
PLUNGERS & PISTONS

For the Benefit of 15 Years Experience in Metallizing, Send Your Job to

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Houston 20, Texas

Suppliers . . .

division of Libbey-Owens-Ford Glass Company. This division has since been merged with other companies to form L. O. F. Fiber Glass.

Alan Wood Steel Company has appointed **C. Irwin Hochhaus** as plant manager for its new Penco Metal Products division. Hochhaus, who formerly was associated with Royal Metal Manufacturing Company, will help coordinate the divisions production and shipment of products.

Kerrigan Iron Works, Inc., is expanding its main offices in Nashville, Tenn. In addition to remodeling its present offices, the company is building a two-story addition to the present structure.

Hamer Valves, Inc., with the licensed manufacturer of its products in England, Joshua Hindle & Sons, Ltd., have appointed Societe d'Etudes Petrolieres as their selling agent in France and the French possessions. The French firm also will assist with the representation of Hamer products in Spain, Italy, Switzerland, Belgium, Luxemburg, West Germany, Yugoslavia, Norway, Sweden and the Netherlands.

The Electric Controller & Manufacturing Company has named **M. E. Young** to succeed **A. A. Piper** as district manager in Chicago. Piper, with the company 24 years, was made a consultant for the company in the Chicago area.

Young, who joined the company in 1930, held his first sales assignment in the Philadelphia office. He has been assigned to the Chicago sales staff since 1940.

Howe-Baker Corporation has appointed **Don S. Rawlings, Jr.,** as a member of its engineering staff. Rawlings formerly was petrochemicals editor for Petroleum REFINER. A chemical engineering graduate from the University of Texas, he joined Neches Butane Products Company at Port Neches, Texas, as a process engineer, following ing his graduation in 1948. He served this company five years, resigning to take a position on the REFINER.

Rawlings

Hercules Powder Company has elected **George B. Baylis** as assistant treasurer. He will be succeeded as secretary of the company by **J. H. Tyler McConnell,** formerly assistant to the president. Baylis will be responsible for problems involving insurance, banking and finance.

Baylis, who has been with the company since 1918, was made assistant secretary in 1941, moving up to secretary seven years later. He had worked in the Engineering, Credit and Accounting department several years, and in 1937 was assigned to the treasurer's staff.

McConnell had been assistant to the president since early 1954. A practicing attorney before he joined Hercules in 1941, he has served as special assistant to the executive committee, assistant general counsel and assistant to the general manager of the Explosives department.

Hooker Electrochemical Company is expanding operations at its Montague, Mich., plant. The company has author-

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a single, central instrument
instantly reads temperatures
at up to 23 locations

WEST MULTI-POINT

HIGH RESISTANCE INDICATING PYROMETERS

Pilot plants, laboratories, power plants, ships and industrial processors are using this efficient and economical method. A Veri-Tell pyrometer, selector switch and terminal panel (plus thermocouples and leads) comprise the unit. Wide selection of scales and ranges. Where thermocouple leads must be of different lengths, calibrating spools may be added.

MODEL IN
Series #3-5-11-17-23 Position, less thermocouples and leads*, $95-$135.

MODEL ISN
Series as above with reference setting.

THERMOCOUPLE SWITCHES
for use with existing instruments.

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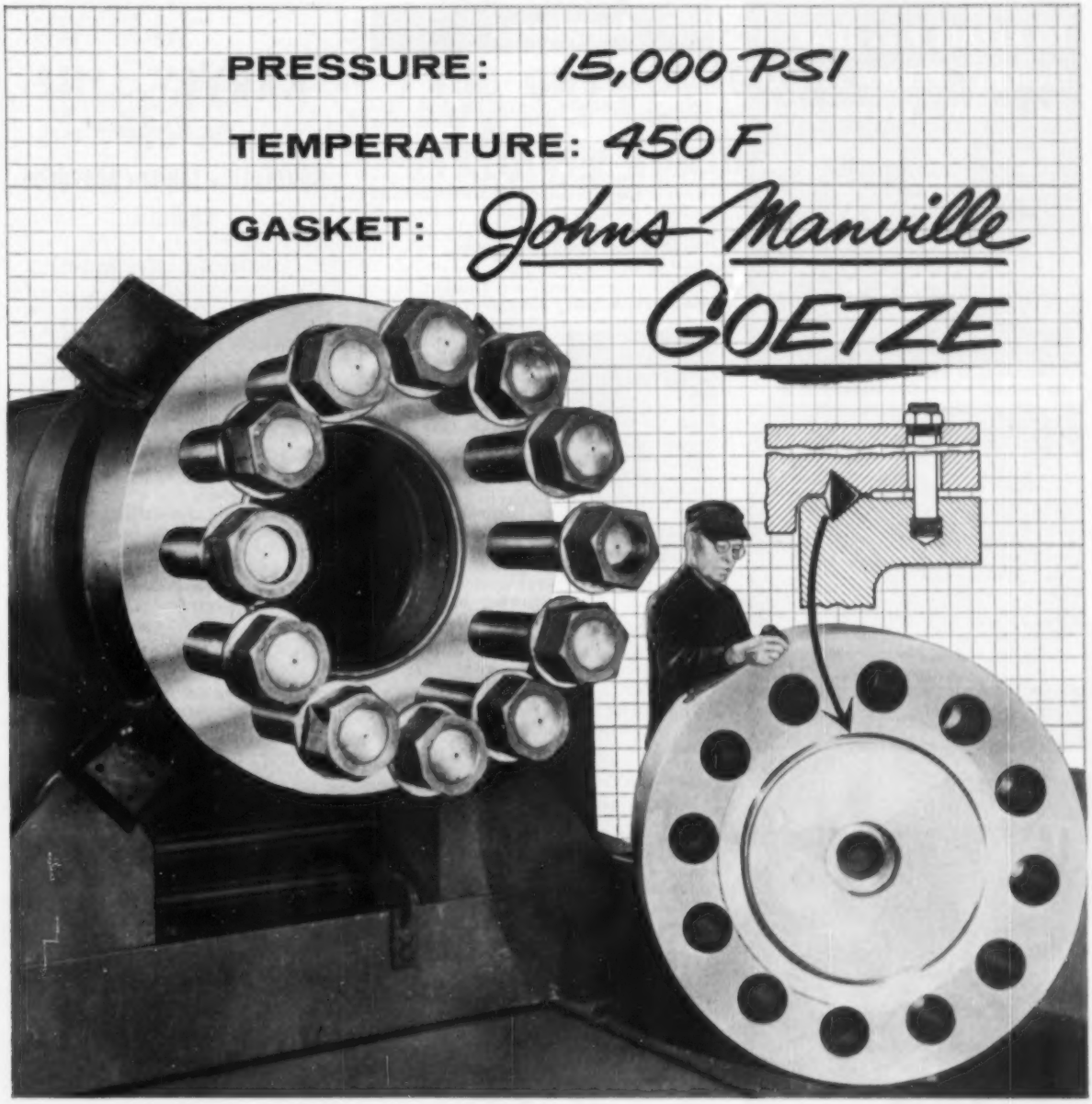


How A. O. Smith maintains tight seals in giant "Multi-Layer" vessels

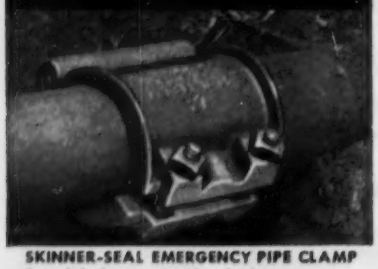
Today's tremendous pressures and temperatures have placed special demands on manufacturers of processing equipment. A. O. Smith has answered this need with a special type of "Multi-Layer" vessel construction. And Johns-Manville in turn has provided gaskets that assure tight seals under these exacting conditions. Typical of these is the delta type gasket, illustrated above, which was designed, for this application, to withstand pressures up to 15,000 psi. and temperatures to 500 F.

The development of special gaskets to meet special purposes has been the stock in trade of Johns-Manville's Goetze division for more than sixty-five years. Expert technicians possess a knowledge of metals and other factors related to gasket design and performance that is unmatched in the field. What's more, intensive specialization and modern production tooling provide substantial cost savings on J-M gaskets.

If you need gaskets for high pressure vessels for similar applications, send us a drawing or template for quotation. If you have a sealing problem of any kind, J-M technicians will work directly with your own engineers to develop new gaskets —or adapt existing styles—to meet your specific requirements. Write for further information to Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit (Toronto), Ontario.

Johns-Manville PACKINGS & GASKETS

TO REPAIR PIPE LEAKS—
QUICKLY, PERMANENTLY
ANY PRESSURE — ANY TEMPERATURE



SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY
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VICTOR ALLOY STUDS

UNIFORM, CLEAN, ACCURATELY THREADED, STRICT ADHERENCE TO SPECIFICATIONS

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Write for the new, easy to use VICTOR catalog.

VICTOR PRODUCTS CORP.
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Suppliers . . .

ized a total of almost $3 million to be spent at Montague during the next year for enlarging the plant and diversifying its product.

Extra facilities will include a hydrogen-chloride compression unit and a hydrogen chloride gas pipeline to adjacent facilities operated by E. I. Du Pont de Nemours & Company. A steam line will be built to the Du Pont plant and Hooker will sell steam to its neighbor.

Western Supply Company has been selected by Brown Fintube Company to serve as sales representative for its heat-transfer line in Kansas, Oklahoma and the Kansas City, Mo., area. **E. D. Anderson,** chief engineer for Western Supply since 1947, is expected to be particularly active in this representation because of his earlier work with the Brown organization. He participated in the development of heat-transfer data on the basic Brown lonitudinal finned surface, and also has had experience in cross-fin application.

Anderson

Borg-Warner Corporation has elected **Howard J. Davis** as president of its Calumet Steel and Franklin Steel divisions. He replaces **W. B. Caldwell,** who retired.

Davis previously was assistant to the president of Colorado Fuel and Iron Corporation. He also had served Colorado Fuel and Iron as manager of its Washington, D. C., office, and as assistant general sales manager for all the company's products. From 1932 to 1940 he held various executive and engineering positions with Carter-Waters Corporation.

Caldwell had been president of the two divisions since 1951. He joined Calumet Steel in 1935 as works manager, becoming vice president and works manager of that division in 1937 and was named vice president and general manager of both divisions in 1947.

Arthur G. McKee & Company of Canada, Ltd., has received an order to build a sulphuric-acid plant for Noranda Mines, Ltd. The plant, when completed in mid-1956, will be the largest sulphuric-acid plant in Canada with a productive capacity of 500 tons a day.

J. F. Pritchard and Company has named **Richard S. Brent** as sales engineer for its Chicago district. He joined the company in 1952 as an application engineer.

Johns-Manville Corporation has elected **C. George Dandrow** to a newly-created position as vice president in charge of customer relations. In his new post, Dandrow will aid company divisions in sales of all the company's products, as well as handle the company's trade-relations activities.

The new vice president, who has been general sales manager of the recently-

The
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48 day cruise of the South Pacific with stop overs in Hawaii, Christmas Island, Tahiti, Acapulco. See Tahiti the Gem of the Pacific in all its grandeur. Four regular sailings yearly.

SPECIAL OLYMPIC GAME CRUISE

Departure from Los Angeles Oct. 1, 1956 for Melbourne, Australia — stopping in route: Honolulu, Samoa, Fiji, New Caledonia, and Sydney. Live aboard ship in Melbourne during games. On return home, stops are made at Auckland, New Zealand, Cook Island, and Tahiti. Return to Los Angeles Dec. 22. Make reservations now to assure seats at the Olympic Games — Limit 36 passengers.

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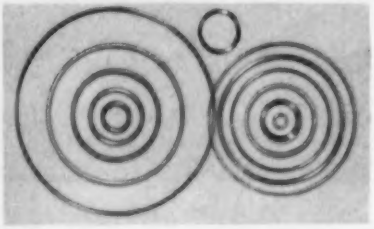

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Since 1906, Chicago-Wilcox has served the refining industry with gaskets for every requirement. These A.P.I. ring gaskets are typical. Used on ring-type flanged joints in high pressure lines. Made of soft iron, standard steel alloys or any of the non-ferrous metals to any desired cross section.

Send specifications for quotations and prompt-delivery schedule.

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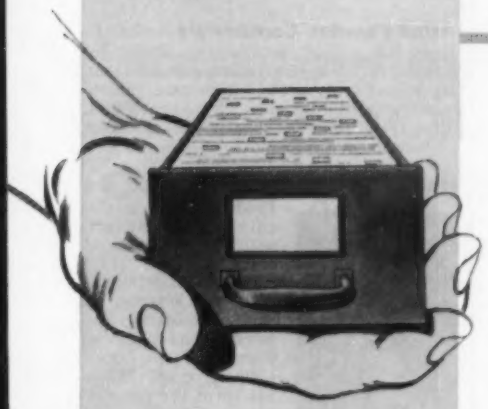

We think we can find the answer to your refinery tubing problems

Maybe we sound confident. But why not? Our tubing specialists have been meeting and solving refinery tubing problems for over 60 years—problems that deal with corrosion, oxidation, acids, high and low temperatures, pressures, exposures, etc. These case histories have been kept on file, and can be tapped for information at any time.

We've used this 60-year-experience file to develop the list of 25 steel analyses shown here. Each analysis was specifically-designed to combat certain refinery conditions, and each one has been tested time and again so that we know its exact capabilities and limitations. Other chemical compositions are also available in tubular products, and a wide variety of high temperature problems are now under study.

So you see why we feel confident to tackle any refinery tubing problem that comes along. Why not send us yours today?

Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

National Tube Division, United States Steel Corporation, Pittsburgh, Pa.
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COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

HERE ARE OUR 25 DIFFERENT STEEL TUBE ANALYSES:

Carbon	8 Cr, ½ Mo
Carbon, ½ Mo	8 Cr, 1 Mo
½ Cr, ½ Mo	9 Cr, 1 Mo
1 Cr, ½ Mo	12 Cr
1¼ Cr, ½ Mo	12 Cr, Al
2 Cr, ½ Mo	17 Cr
2¼ Cr, 1 Mo	18-8
2½ Cr, ½ Mo, ¾ Si	18-8 Ti
3 Cr, 1 Mo	18-8 Cb
5 Cr, ½ Mo	18-8 Mo
5 Cr, ½ Mo, 1½ Si	25-20
7 Cr, ½ Mo	3½ Ni
5 Ni	

SEAMLESS WITHOUT WELDS

NATIONAL SEAMLESS PIPE AND TUBES

USS

UNITED STATES STEEL

FLEXIBLE BARCO BALL JOINTS

Loads 5,000-gal. Truck in 30 Minutes
One man can fill a 5,000-gal. trailer in about 30 minutes on this new, expanded Asphalt Loading Rack built by American Liberty Oil Company at Mt. Pleasant, Texas. Over 60 trucks per day are loaded here.

How Barco Simplifies Loading 500°F. Asphalt

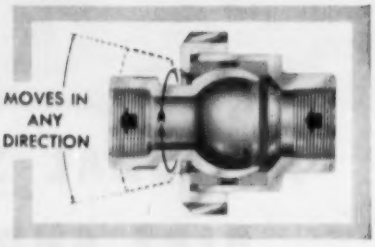
Problem — To make heavy, viscous asphalt flow freely, processors and producers frequently heat it to 500°F., or even higher. Ordinary movable loading line joints frequently fail at such temperatures.

Solution — The Mt. Pleasant, Texas, refinery of American Liberty Oil Company, like many others, solved this problem by using Barco Flexible Ball Joints. These joints hold their seal at high temperatures. Even more important is the fact that a loading line can be made with *just one* 4" Barco Style 7F-8F joint (see arrow) which provides over 30° of flexibility in any direction.

Engineering Recommendations — Barco will be glad to make detailed recommendations to meet your requirements. See your local Barco representative or write for a copy of new Catalog 215B.*

*New steam jacketed Barco Ball Joints are now available.

BARCO Manufacturing Co.
542M NORTH HOUGH STREET
BARRINGTON, ILLINOIS



Suppliers . . .

split Industrial Products division, continues as vice president of Johns-Manville Sales Corporation, a position he has held since 1946.

Atlas Powder Company's Arthur L. Frost has retired as manager of the Industrial division's Engineering department. He joined Atlas in 1941 to become general manager of the Ravenna Ordnance Works, after 11 years as assistant general manager of Sargent & Company.

Hammond Iron Works has appointed **Fred J. Myers** as district sales manager, with headquarters at Warren, Pa. The company maintains a plant at Warren, as well as at Bristol, Pa., Birmingham, Ala., Provo, Utah, and Casper, Wyo. Myers has spent the past few years with Lukens Steel Company and before that was associated with Welding Engineers, Inc.

Myers

The Otto H. York Company, Inc., has named **Edward G. Scheibel** as director of engineering. Dr. Scheibel's major responsibilities will be design and development of chemical process equipment, with emphasis on extraction, distillation and mist-eliminating equipment.

Dr. Scheibel was with Hoffman La-Roche ten years, resigning as head of the Chemical Engineering department to join the York company. Previously he was process design engineer with both Hydrocarbon Research, Inc., and The M. W. Kellogg Company.

Crane Packing Company has broken ground at Morton Grove, Ill., a Chicago suburb, for two new buildings to house its research and laboratory operations, as well as offices and a cafeteria. Marking the culmination of a three-year program, these buildings are in addition to a new factory building already in operation. When the project is completed in early 1956, the company will have a new 17-acre home site for its manufacturing and service operations.

Byron Jackson Division, Borg-Warner Corporation, is expanding its business development program, and has appointed **John W. Rumery** to head its increased activities. For the past several years, Rumery has been engaged in the investment business in Southern California.

Union Carbide and Carbon Corporation has appointed **J. M. Cole** and **J. H. Mathewson** as product managers and **George Trigaux** as assistant product manager in the Fine Chemicals division of its Carbide and Carbon Chemicals Company.

Cole will be in charge of market development for chemical intermediates, and Mathewson will be responsible for developing markets for plasticizers and stabilizers for vinyl resins. Trigaux, transferred from the company's South Charleston plant where he was area supervisor in

Rats and termites leave U. S. Matchless® Carbolized Fire Hose alone!

These two types of pests eat up a lot of fire hose each year. (Most people are surprised to learn that termites and rats will eat fire hose. Yet in just one plant in Texas, over 600 feet of hose were eaten in a year by these ever-hungry vandals.)

But rats and termites can't abide U. S. Matchless Carbolized Fire Hose, because of its special construction features. A fire chief in one refinery has already bought over 10,000 feet of U. S. Matchless in just one year. He knows a fire hose has to be ready in emergencies to deliver full flow of water under required pressure.

U. S. Matchless is made for hard service and to resist rot and mildew. Its special carcass contains two spirally-applied plies of "Ustex" tire cord fabric, which make it light, flexible, easy to handle, roll or rack. Its white (or black) oil-proof neoprene cover resists oils, acids, fumes and strong sunlight. Lightest and most flexible *covered* fire hose on the market; withstands 400 lbs. test pressure.

Get in touch with any of the 27 "U. S." District Sales Offices or write Mechanical Goods Division, Rockefeller Center, New York 20, N. Y.

"U. S." Research perfects it
"U. S." Production builds it
U. S. Industry depends on it.

US RUBBER

Mechanical Goods Division

United States Rubber

For more data on advertised products, use Readers' Service Cards, last page.

Red light for contamination

Hungry organic acids used at Newport Industries' Fine Chemical plant in Pensacola, Florida are stopped in their tracks by the Aloyco valves in this picture.

Made of an alloy so tough it can't be corroded, these valves prevent costly contamination of the fine chemicals and eliminate frequent valve replacement.

Newport picked Aloyco valves for still another reason. They knew these versatile valves could handle other chemicals *at any time*—assuring unusual flexibility for the plant.

Now you know why so many leaders in the chemical field specify Aloyco corrosion-resistant valves. Alloy Steel Products Co., Inc., 1301 West Elizabeth Ave., Linden, N. J.

5.8

Longer Lasting
ALOYCO
VALVES
SET IN CORROSIVE SERVICE

See Aloyco Valves at CHEMICAL SHOW Booth 35

Aloyco Valves like those opposite will star at the CHEMICAL SHOW. They'll be on display—along with Aloyco Valves for every type of corrosive service—at the ALLOY STEEL PRODUCTS Booth. And an Aloyco representative will be on hand to show you how you can put them to work tackling corrosion in your plant.

Even if you can't make the show, you can still get all the information you need on Aloyco Valves from one of Aloyco's distributors or sales offices. Just write or call at the address below that's nearest you. ALLOY STEEL PRODUCTS COMPANY, INC., 1308 West Elizabeth Ave., Linden, New Jersey. 59

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Buffalo 14, New York
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Chicago 4, Illinois
McCormick Bldg.
332 S. Michigan Ave.
Los Angeles 22, Calif.
1238 S. Atlantic Blvd.
New York City 1, N.Y.
Empire State Bldg.
350 Fifth Avenue
Pittsburgh 22, Pa.
310 Investment Bldg.
San Francisco, Calif.
24 California St.
Wilmington, Delaware
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Republic Supply Company of California
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Republic Supply Company of California
1919 Williams Street, San Leandro
Florida:
Mineco Incorporated
P. O. Box 882, Bartow
Massachusetts:
Industrial Steels, Inc.
250 Bent St., Cambridge
Oklahoma:
Ardun Supply Company
303 S. Frankfort St., Tulsa
Texas:
K. E. Luger Company
P. O. Box 6704, Houston 5
Utah:
The Galigher Company
545 West 8th, South St., Salt Lake City 4
Washington:
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2453 Sixth Avenue, South, Seattle 4
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Railway & Power Engineering Corp., Ltd.

EXPORT OFFICE

Frederick von Raab
P. O. Box 350, Port Washington, N. Y.

Suppliers . . .

charge of one of the production units, will assist Cole.

L. O. F. Glass Fibers Company, planning to build a new research center at Waterville, Ohio, has named **Dominick Labino** as vice president and director of research. He previously was vice president in charge of glass research and process development.

The new center, a 32,000-square-foot building, will be located near the company's manufacturing facilities in Waterville. Contract for construction of the new unit went to Floyd P. Bucher & Son, Inc. Work was to start immediately.

Labino, with the company in various managerial posts since 1947, was the first man to synthesize quartz in micro-fiber form, a discovery announced in 1951.

H. K. Porter Company, Inc., has elected **Robert C. Houser** treasurer. **Rocco J. DiFonso** was named assistant treasurer, and **Edward R. Moran** was made assistant secretary.

Houser, who joined Porter more than a year ago as assistant treasurer, previously had been manager of the Pittsburgh plant of Peat, Marwick, Mitchell & Company. Moran, before joining Porter, was a partner in the Toledo law firm of Cobourn, Yager, Notnagel, Snith & Moran. DiFonso was with the Bureau of Internal Revenue before joining Porter's Accounting department in 1951.

American Iron & Machine Works Company, Inc., has formed a Canadian subsidiary. The name of the new company is American Iron & Machine Works (Canada), Ltd. Serving as officers of the new subsidiary are **M. G. McCool,** named president; **E. E. Rubac,** vice president, and **J. E. Vogt,** secretary and treasurer.

American Cyanamid Company has retired **Norman A. Shepard** as chemical director. With the company since 1936, Dr. Shepard has been connected with the chemical industry 43 years.

He started as a chemistry instructor at Yale University, stepping up to assistant professor four years later, and in 1919 joined Firestone Tire and Rubber Company as director of organic chemical research. He was made director of research in 1925.

Leeds & Northrup Company has made several changes in managerial responsibilities in its field sales organization, including the promotion of **William L. Kimber** to district manager in the Buffalo office. A sales engineer at Buffalo since 1940, he replaces **Joseph M. Jackson,** who was named as manager of the Philadelphia district sales office.

W. Spencer Bloor, a sales engineer in the Chicago office since 1946, was promoted to district manager at Atlanta, Ga. He succeeds **William A. Macan, III,** who was appointed manager of the Cleveland district sales office.

L. O. F. Fiber Glass Company has appointed **James J. Secor, Jr.,** as sales manager for the Philadelphia area. He will headquarter at the company's branch office at Narberth, Pa. He formerly was a district sales manager for Libbey-Owens-Ford Company.

Zimmerman

Bothwell

Wolverine Tube, Division of Calumet & Hecla, Inc., has made two new assignments to its general sales office in Detroit. **Don F. Zimmerman** was named to take over a position in the company's Advertising department, and **William Bothwell** was assigned to new responsibilities in its Aluminum department.

Formerly a Wolverine sales representative in the New York-New Jersey area, Bothwell has been with the company five years. Zimmerman, who has been with the concern for the past 11 years, was transferred to his new post for the Industrial Engineering department at Wolverine's Detroit plant.

Union Carbide and Carbon Company has named **Sheldon V. Clarke** as manager of its General Purchasing department. He succeeds **H. V. Huffard,** who retired after 40 years with the company.

Clarke first joined the Union Carbide organization in 1920. He served as construction engineer in the Construction and Design department of Linde Air Products Company and later held the same position with Carbide and Carbon Chemicals Company.

In 1929 he left Union Carbide and joined Bradstreet Company, becoming a vice president. Clarke returned to Union Carbide in 1934 as purchasing agent, and in 1946 he was appointed assistant manager of purchases.

Johns-Manville Corporation will split its present Industrial Products division into three new operating divisions, the Industrial Insulations division, the Packings and Friction Materials division and the Pipe division.

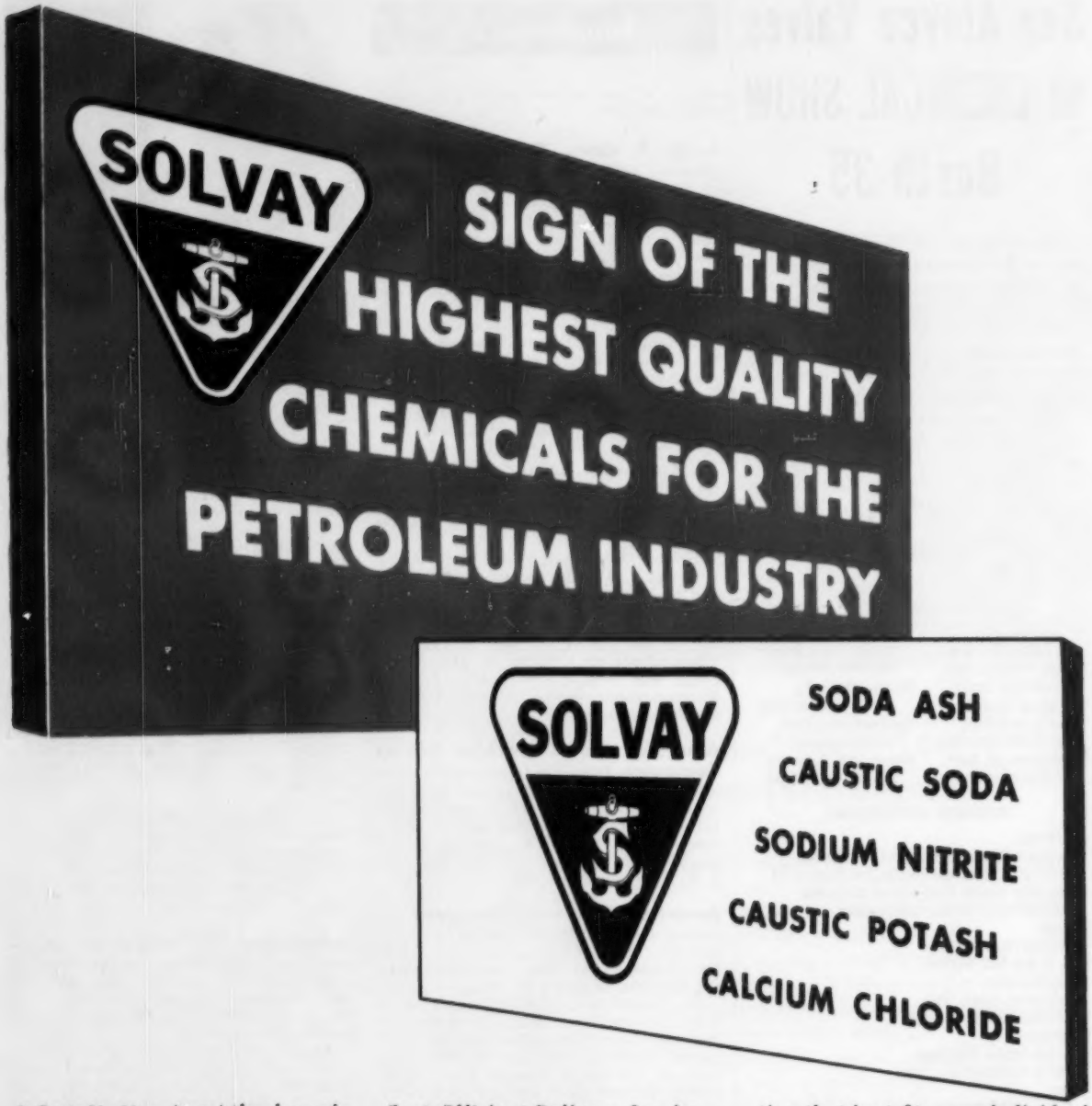
General manager of the new Industrial Insulations division will be **Don L. Hinmon** who also has been elected vice president of Johns-Manville Sales Corporation. Other division managers are **Francis J. Wakem,** Packings and Friction Materials, and **Robert F. Orth,** Pipe division.

Ladish Company has purchased two adjacent Los Angeles manufacturing plants. They belonged to CBS Steel and Forge Company and General Pacific Corporation. The plants will be operated as the company's Ladish Pacific division.

General Electric Company has named **Howard D. Kurt** as product planning specialist and **Alton J. O'Neil** as marketing research specialist for the Distribution Assemblies department. Kurt will be responsible for the administration of all product planning for the department, and O'Neil will have charge of all special marketing research projects. Both will headquarter at Plainville, Conn.

Kurt formerly was an application engineer with General Electric's Industrial Power Application Engineering unit with

For more data on advertised products, use Readers' Service Cards, last page.



It Costs No More to get the *dependable quality* that has made Solvay the world's largest producer of alkalies and associated chemicals.

Solvay Quality is the result of combining the nation's finest alkali manufacturing facilities with the experience gained in the 74 years that Solvay has been producing alkalies.

Fast, Efficient Delivery Service—Solvay's nation-wide chain of great manufacturing centers and over 200 strategically-located supply points are in a better position to make prompt deliveries—especially during your peak months.

Whether You're a Small or Large Refiner—you're always sure of receiving the close, personal attention that best fits your individual needs! Your specific requirements are handled by Solvay's trained and experienced local field representatives operating out of Solvay's 13 branch offices.

For Quality . . . Dependability . . . Service—make your first call Solvay by phoning or writing the Solvay office nearest your plant.

Soda Ash • Snowflake® Crystals • Potassium Carbonate • Calcium Chloride
Sodium Bicarbonate • Ammonium Bicarbonate • Cleaning Compounds
Caustic Potash • Sodium Nitrite • Caustic Soda • Ammonium Chloride
Monochlorobenzene • Para-dichlorobenzene • Ortho-dichlorobenzene
Chlorine • Chloroform • Carbon Tetrachloride • Methylene Chloride
Methyl Chloride

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL & DYE CORPORATION
61 Broadway, New York 6, N. Y.

Allied Chemical

BRANCH SALES OFFICES:
Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • St. Louis • Syracuse

the Apparatus Sales division in Schenectady, N. Y. O'Neil takes over his new assignment after serving with the company's Management Consultation Services division in New York.

Abbott

Waples

The Garlock Packing Company has elevated its president, **George L. Abbott**, to chairman of the board, with a designation as chief executive officer. He is succeeded by **Robert M. Waples**, who moved up from the executive vice presidency he had held since 1952.

Elected vice president was **William M. Sheffeld**, assistant to the president since 1952. He had previously served the company as a staff attorney for three years.

Abbott, who joined Garlock in 1911, had been president since 1928. Waples previously served the company as a branch clerk, sales representative, assistant to the general manager, Service department manager and as vice president.

Carbide and Carbon Chemicals Company, has opened a new sales office in New Orleans. This is the 26th sales office established by the company, a division of Union Carbide and Carbon Corporation. **J. T. Fox** is the technical representative assigned to the new office.

Ethyl Corporation has elected **B. Bynum Turner**, vice president in charge of research and engineering, to a newly-created position as executive vice president. He will be succeeded by **George F. Kirby**, who joined the company as a chemist 15 years ago.

Turner

Turner joined Ethyl in 1946 as assistant manager of its Baton Rouge, La., plant. He later became general manager of manufacturing and was named to head the research and engineering program in 1951. He is a director of Ethyl Corporation and Ethyl Dow Chemical Company.

As a result of the Turner and Kirby promotions, other organizational changes in the research and engineering force were made as follows:

Francis J. Sergeys, director of the Chemical Engineering division, was promoted to general manager of research and engineering operations at Baton Rouge, succeeding Dr. Kirby. Sergeys joined Ethyl in 1940 and later served six years as special assistant to the vice president in charge of manufacturing.

Paul A. McKim, assistant director of process development was named to replace Sergeys in the Chemical Engineering division. Dr. McKim has been with the company since 1949.

Alloy Steel Products Company, Inc., has elected **Raymond M. Davis** to succeed his brother, the late **Jack Davis**, as president of the company. The new president joined the company in 1935, handling both production and sales assignments. He successively served as sales manager and vice president. He is a member of the board of directors.

Walworth Company has purchased the assets and business of Southwest Fabricating & Welding Company, a Houston firm. Southwest Fabricating, international supplier in the oil, chemical, petrochemical and natural-gasoline fields, will operate as a Walworth subsidiary. The company will retain its present management, employes and policies.

Suppliers . . .

Hooker Electrochemical Company and Niagara Alkali Company have agreed to consolidate. Under the terms of the agreement, still to be approved by the stockholders of the two companies, Hooker would be the continuing concern. Plans for the merger call for 1.6 shares of Hooker common stock to be exchanged for each share of Niagara's common stock.

Arthur G. McKee & Company plans to expand its home office and engineering facilities in Cleveland. The company will build a new $500,000 two-story building, to add about 35 percent to the present

Florex—for adsorption

Recognized throughout the world as superior to all other natural clays used in adsorption processes, Florex is particularly effective in the adsorptive refining, decolorization, clarification and neutralization of mineral, vegetable, and animal oils, fats and waxes. Florex is also effectively used for sweetening light distillates, dehydration, desulfurization and polymerization.

Florex is prepared from carefully selected natural Florida Fullers Earth by a special processing including high-pressure extrusion, which greatly improves adsorptive efficiency and capacity.

Standard particle sizes are herein reproduced and include meshes from 2/4 to 200/ up. Special meshes are also available. Florex is packaged to fulfill customer's requirements with the Fifty (50) pound non-returnable paper bag the minimum quantity.

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100-UP
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For more data on advertised products, use Readers' Service Cards, last page.

PIPING LAYOUT IS SIMPLER with Gentile* FLOW TUBES

...THEY NEED SO LITTLE ROOM

Gentile Flow Tubes are short. They need only minimum straight runs entering and following, and can be installed at practically any accessible point where flow conditions are reasonably steady.

Flow Tubes are furnished with individual head capacity curves, and for unusual piping arrangements, calibration curves for simulated conditions can be furnished.

Guaranteed

- Accuracy
- Minimum Head Loss
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*GEN-TIL-LY

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE — UNION, N. J.

AUTOMATIC VALVES • CONTROL VALVES • SAFETY VALVES • FLOW TUBES

Suppliers . . .

floor space of its home office. Instead of enlarging the present building, it was decided to build a separate structure, permitting the latest design in offices and engineering facilities and enabling the company to expand more readily in the future.

Houdry Process Corporation today has named **Philip A. Burghart** as head of the market development section of its Chemicals division, with headquarters in Philadelphia. Burghart formerly was with the Antara Chemicals division of General Aniline and Film Corporation, first with the Central Research unit in Easton, Pa., and more recently in the Organic Intermediate Sales and Development division in New York.

Burghart

Petroleum Electric Power Association has elected **Fred B. Clark**, with Arkansas Power & Electric Company in El Dorado, Ark., as president. The new vice president is **F. R. Woerner**, Texas Electric Service Company, Fort Worth, Texas, and the secretary-treasurer is **J. F. Maddox**, New Mexico Electric Service Company, Hobbs, N. M.

Those elected as directors are **W. L. Thomson**, Gulf States Utilities Company, Beaumont, Texas; **U. H. Ohrman**, Texas Power & Light Company, Dallas, **Harvey Cherry**, Houston Lighting and Power Company, Houston, and Clark, Woerner and Maddox.

Atlas Powder Company has cleared **Benjamin J. D. Bruff** for retirement. Assistant to the director of explosives sales, he is retiring after more than 43 years with the company. Bruff has been associated with the company's Knoxville, Tenn., district explosives sales office since 1913, and for more than 17 years he served as its manager.

Solvay Process Division, Allied Chemical & Dye Corporation, will begin construction of a mercury cell chlorine-caustic soda plant near Brunswick, Ga. The new plant is expected to be in production by December 1956.

Construction of the Brunswick plant will be under the supervision of **C. P. Hackett**, Solway's director of development. Engineering work in connection with design of the plant will be carried on by Solvay's own forces.

Chicago Bridge & Iron Company has made three new appointments in its sales organization. **Robert S. Chamberlain** was assigned to the San Francisco sales office; **Arthur G. Albertson** was sent to the office in Los Angeles and **Julius D. Holmquist** was stationed with the staff in Philadelphia.

O. C. Keckley Company now combines its general offices and manufacturing facilities in a new plant recently completed at Skokie, Ill., near Chicago. The company previously had its general offices

in Chicago and carried on its manufacturing operations in Springfield, Ill.

The Fluor Corporation, Ltd., has formed Prairie Pipe Company, Ltd., to manufacture steel pipe for the oil and gas industries. Operating as an affiliate, the new company's 100,000-ton-a-year plant will be located on the outskirts of Regina, Sask. The plant, scheduled to go into operation April 1, 1956, represents a total investment of more than $3,500,000. Construction will begin immediately. Fluor Corporation of Canada will construct the plant. Cal-Metal Corporation has been awarded a contract to furnish all the machinery and equipment for the plant.

J. E. Cunningham, former district engineer for Fluor in Houston, has been named vice president and general manager. He will be located at Regina.

Phillips Chemical Company has made several appointments to staff the new Plastics Sales division. **W. C. Douce, J. T. Roach, R. G. Askew** and **C. R. Scott** were named district managers for Plastics Sales division offices to be established next spring in New York, Chicago, Los Angeles and Boston. **W. R. Barrett** and **G. F. Blinzler** will become sales engineers for the Boston and Chicago district offices.

M. W. Davidson has been named supervisor of the Sales Service and Development branch of the Plastic Sales division's Bartlesville office, and **L. B. Croley, J. V. Smith,** and **A. L. Walters** will become sales service engineers in that branch.

Previous appointments to staff the plastics sales division were **George Wash,** director and sales manager; **Walter R. Clarke,** assistant sales manager; **R. Vernon Jones,** manager, technical service and development; and **R. M. Wallace,** administrative assistant and coordinator.

Until the new district offices are established, the district managers and sales engineers will operate from the company's Bartlesville headquarters in establishing contacts with representatives of plastics products fabricators in their areas.

Atlas Powder Company has realigned its chemical research and development organization and staff to strengthen long-range research and product diversification programs. The reorganization is expected to result in an expansion of chemical research facilities and personnel in the next few years, with increased emphasis on basic research. As part of the new program, product development work on activated carbons will be transferred from the company's Darco Experimental Laboratory in Marshall, Texas, to Wilmington, Del.

The Pfaudler Company has set up an Applications Engineering section. **John W. Cosier** will head the new group. Engineer in charge of the new section, he had been working with Pfaudler in Project Engineering. He was formerly with Jefferson Chemical Company.

Rheem Manufacturing Company has given two of its vice presidents new management assignments. They are **G. M. Greenwood,** named chief financial officer, and **Gordon Mallatratt,** appointed secretary and treasurer.

Mallatratt, who succeeds Greenwood as secretary and treasurer, has been general manager of the Rheem Products division. **Vearl J. Heinis,** general sales manager for Rheem Products division, will succeed Mallatratt as general manager of that division.

Pacific Coast Borax Company, division of Borax Consolidated, Ltd., is starting work to convert its present system of mining at Boron, Calif., to open-pit and to construct new concentrating and refining plants at the minesite. Recent developments in technique and equipment now make possible the recovery of virtually the entire orebody at Boron by open-pit methods.

The Patterson Foundry and Machine Company has elected **John M. Roberts, IV,** as executive vice president and **Dean M. Wilhelm** as vice president and technical adviser. **Thomas G. Coyne** joined the company as controller.

Roberts formerly was secretary and treasurer, and Wilhelm was vice president. Coyne previously had been in charge of the Cost Planning department of Pittsburgh Plate Glass at Pittsburgh.

Suppliers . . .

Olin Mathieson Chemical Corporation has named **John J. Forst** as sales representative, in Detroit, Mich., and **R. E. Bockhorst** was named sales representative in Dayton, Ohio.

Forst had been technical representative in the Metals Division. He joined Olin Industries in April 1953 as staff assistant to the sales manager.

Consolidated Chemical Industries, Inc., has promoted three of its executives.

R. D. Allison will be assistant to the Resident Manager at the Woburn, Mass.

ALCO-LITE aluminum ladders are Safer-Longer!

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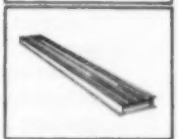
25 years ago the first aluminum ladder was bought by the New Kensington, Pa. Fire Department. After 13 years of fire fighting and 12 years of general duty, without a single repair, this ALCO-LITE Aluminum Ladder is still in excellent condition.

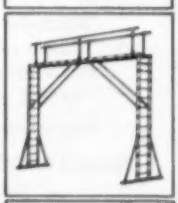
1 because they're aluminum

ALCO-LITE Ladders are made of lightweight, high tensile strength aluminum alloy. They are approximately twice as light and strong as similar ladders made of wood. You will find them easier to lift — easier to carry — easier to use. They will never rust, rot, splinter, spark or burn. ALCO-LITE Aluminum Ladders require almost no maintenance.

2 because they're ALCO-LITE

This nameplate is your assurance of having an aluminum ladder that will withstand the hardest industrial use. Exclusive ALCO-LITE design and construction make it perform better — safer — longer. Every ladder more than meets the rigid code and tests of the ASA and Metal Ladders Association.





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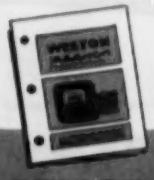

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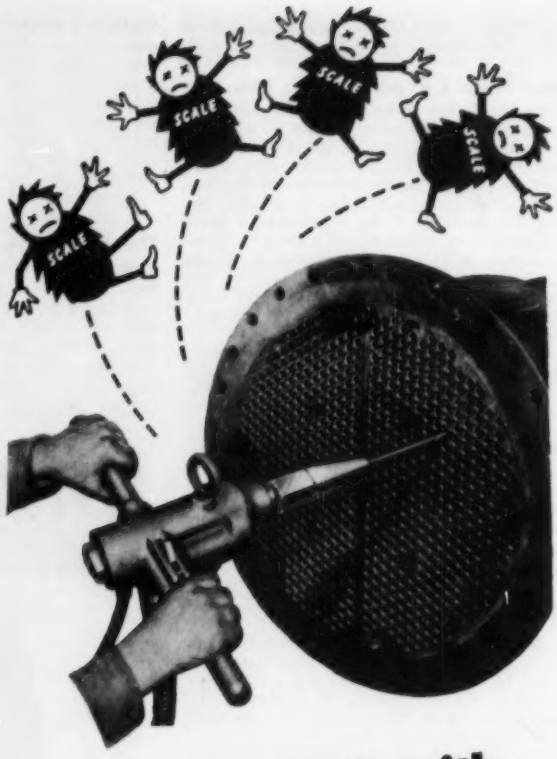

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Are your tubes completely fouled with scale buildup? Or, are you looking for that last vital inch of heat transfer efficiency? In either case, efficient hard-working Wilson Tube Cleaners are the answer.

Wilson brings you a complete line of fast-acting tube cleaners. They handle every kind of deposit, hard or soft, thick or thin or variable in depth. Driven by air, steam, water or electricity, these powerful cleaners make quick work of cleaning straight or curved tubes.

For heavy duty service, for example, use Wilson Model TP 301 shown above. This tube cleaner is suitable for vertical or horizontal use in straight or curved tubes ⅜" ID to 2⅞" ID and up to 40' long. Cleans rapidly, thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi.

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plant. He has been with Consolidated since June 1951 and has moved from Ft. Worth where he was engineer of the acid plant.

A. L. Stephenson was made assistant plant manager at Bayshore, Calif. Stephenson has been with Consolidated since 1933. He was in charge of maintenance at the Ft. Worth acid plant before his transfer to California.

C. E. Spear was appointed director of development for the Pacific and New England divisions. He will make his headquarters in the company office at San Francisco. Spear was formerly associated with Monsanto Chemical Company.

Union Carbide and Carbon Corporation has made **Sheldon V. Clarke** manager of general purchasing. He succeeds **H. V. Huffard** who is retiring after 40 years with the Corporation.

Clarke first joined the Union Carbide organization in 1920. He served as construction engineer in the Construction and Design department of Linde Air Products Company and later held the same position in Carbide and Carbon Chemicals Company. In 1929 he left Union Carbide and joined the Bradstreet Company, becoming a Vice President. Clarke returned to Union Carbide in 1934 as purchasing agent. In 1946 he was appointed Assistant Manager of Purchases.

Joy Manufacturing Company has appointed **J. E. Douglas** as district sales manager of its company's El Paso territory. He succeeds E. E. Miller who has retired after 43 years service.

Earlier this year, Douglas was appointed assistant district sales manager at El Paso. He joined the Joy organization in 1945 and was assigned to the Birmingham-Knoxville territory. In 1950, he was transferred to the Phoenix area of the El Paso district as Sales Engineer.

Robert M. Van Tassel has been named head industrial designer for the company, attached to its Pittsburgh executive staff. With Joy seven years, he previously was engaged in product development and design for the Cadillac Division of General Motors.

Du Pont Company will build a new sulfuric acid plant near the confluence of the Ohio and Greater Miami Rivers, about 20 miles downstream from Cincinnati. Construction is to start immediately and the plant is scheduled to start operations in late 1956.

To be known as the Fort Hill Works, the new unit will be built by the Du Pont Engineering department and will be operated by the company's Grasselli Chemicals department. It will replace the plant now operated by Grasselli at Lockland, near Cincinnati. The Lockland Works will continue operations until the new plant is in commercial production.

Wolverine Tube, Division of Calumet & Hecla, Inc., have moved its sales offices to larger quarters in Louisville, Ky. The new offices will become the sales headquarters for the company's sales representative, Jack Sheehan.

The International Nickel Company has added **E. M. Uebel** and **K. H. Kirgin** to the Ductile Iron Section of its Development and Research division. The section is being expanded. Uebel served four years as metallurgist and assistant to the superintendent at Eagle Foundry Company, producers of ductile iron in Seattle, Wash., and Kirgin spent four years with the American Brake Shoe Company at its gray iron foundries in Mahwah, N. J., and Melrose Park, Ill.

J. F. Pritchard & Company has selected W. H. Kidd and Company, of Richmond, as sales representative for Virginia. The Kidd organization, founded in 1948, is headed by **W. H. Kidd**, a Massachusetts Institute of Technology graduate and former sales representative in the East for the Foxboro Company.

Petro-Chem Development Company has picked Rawson & Company, a Houston firm, as its representative for Louisiana, southern Arkansas and all Texas except the Panhandle. William H. Mason Company, in Tulsa, was selected to handle northern Arkansas and Kansas City.

Suppliers . . .

Harbison-Walker Refractories Company has appointed **Jack L. Ziercher** as manager of market research. A graduate of the University of Missouri, Mr. Ziercher received his B.S. degree in chemical engineering in 1943, and his M.B.A. degree in 1949 from the Harvard Graduate School of Business Administration and has been in market research work since graduation.

Walworth Company has made **Joseph E. Mihm** an assistant vice president. He will be in charge of the company's West Coast operations, with headquarters in San Francisco. Previously he

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Suppliers . . .

served as Central division sales manager of Walworth with headquarters in Pittsburgh, Pa. He has been associated with the company for 20 years, working in the company's offices at Pittsburgh and Detroit.

A. O. Smith Corporation has named **W. M. Asher** sales manager for hydraulic products at the Los Angeles plant. For the last three years he has been sales manager for the company in Houston, Texas.

The company has appointed **William C. Powell** as district sales manager for the Tubular and Process Equipment division. He formerly was sales manager for the Tubular Products division. **Joseph Coffman** has joined the company's Process Equipment division and will work out of the Chicago regional office.

Worthington Corporation has named **Ralph G. Griffin** manager of its Cincinnati district office. Griffin, with Worthington since 1930, succeeds Earle W. Vinnedge who has been named special representative of the Cincinnati office concentrating on large negotiations. Vinnedge has been with Worthington Corporation for 40 years and he has served as the Cincinnati District Office Manager for 28 years.

Rheem Manufacturing Company has elected **Angus Lightfoot-Walker**, vice-president in charge of Rheem International, a director of the parent company. Walker joined Rheem Australia as sales manager in 1937. He became general manager before transferring to New York as executive assistant to the president. In 1951 he became vice president in charge of Rheem International, which handles Rheem's overseas investments and sales.

Rockwell Manufacturing Company will begin construction of a 100,000-square-foot warehouse, assembly and repair plant at Porterville, Calif. The new plant, expected to be completed by early 1956, will cost approximately $1 million.

A one-story concrete-and-tile structure on a 32-acre plot, it will be used for assembly, repair and warehousing of Rockwell meter and valve products for West Coast distribution—also for warehousing.

Ethyl Corporation has placed in operation a new Houston gasoline testing laboratory.

The laboratory, part of Ethyl's nationwide gasoline testing service, will also house the company's district office.

Diamond Alkali Company has leased 45 tank cars recently purchased by Mutual Life Insurance Company of New York. The lease was made on a long-term basis, with renewal options.

Thirty seven of the cars will be used to transport caustic soda; the other eight, chlorine. The cars were built by General American Transportation Company and American Car & Foundry Company.

As part of its fleet, Diamond Alkali also is operating 114 tank cars and two steel barges which it leased from Mutual of New York earlier this year.

The Patterson Foundry & Machine Company has appointed Joseph B. Burg as works manager of its East Liverpool, Ohio, plants. Burg was formerly with ALCO Products, Inc., serving as superintendent of the Heat Exchanger and Process Equipment division at the Dunkirk, N. Y., plant.

Davison Chemical Company, Division of W. R. Grace & Co., has installed new production facilities at plants in Lansing, Mich., Columbus, Ohio, and Nashville, Tenn., bringing its total hydrofluosilicic capacity for acid to more than 14,000 tons annually. Davison has in the engineering stage additional facilities which will be installed later.

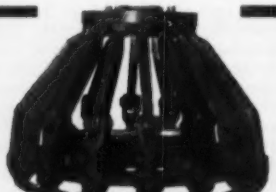
Borg-Warner Corporation has selected **Joseph M. Gartner,** previously assistant patent counsel, as administrative assistant to the president of the corporation.

Atlas Powder Company has completed a $100,000 nitration process laboratory at its explosives experimental laboratory near Tamaqua, Pa. The new laboratory is a pilot plant installation which will allow studies of nitration reactions in plant-type equipment.

More Suppliers' Notes on Page 317

Free Booklet on Technical Writing

PETROLEUM REFINER has prepared a booklet for the editors and those within the industry who may write technical articles for PETROLEUM REFINER or others of the technical press. This booklet also contains valuable suggestions on preparing papers for technical meetings or reports. Each subscriber to PETROLEUM REFINER may have a copy free of charge, just by asking for it. Use the blue "Reader's Service" card on the back of this issue. Write in "Free Author's Booklet," fill in name, address and mail. No charge, no obligation.



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NEW

OAKITE COMPOUND No.85

Here is good news for refineries that are using a two-material cleaning procedure for removing the tenacious, heavy soil customarily found in refinery equipment. You no longer need use a solvent cleaner for the removal of greases and oils and then an acidic material for carbonaceous deposits, iron oxides and sulphides.

Oakite now offers a new detergent, Oakite Compound No. 85, that does both cleaning jobs in one and the same operation. You can remove both types of soils – greases and oils as well as carbonaceous deposits, iron oxides and sulphides.

Oakite Compound No. 85 when circulated as directed, gives you these important advantages:

- **Thorough cleaning action in a single cleaning operation**
- **High penetrating action that quickly cuts through heaviest soil**
- **Inhibited against attack on steel**
- **Long solution life**
- **Free-rinsing**
- **Safer and more effective than raw acid**
- **No offensive odor**

O. C. No. 85 is particularly recommended for cleaning and conditioning absorbers, debutanizers, deethanizers, feed stock preheaters, heat exchangers, and stabilizers. For further information and details, write for Bulletin F-3751. Or, if you prefer, contact your nearby Oakite Technical Service Representative. Oakite Products, Inc., 50B Rector St., New York 6, N.Y.

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What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

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The Klinger Seatless Piston Valve operates on an entirely different principle from the usual type of seating valve. It consists basically of a finely ground piston, operated by the valve spindle and hand wheel and moving through two or three non-metallic resilient valve rings, capable of resisting steam, oil and most fluids at high temperatures and pressures, and separated by a ported lantern bush. It is made in a great variety of sizes and designs, to suit all purposes, and has the following advantages:-

No seat—consequently no regrinding.
Can be serviced in the line.
Unaffected by wiredrawing.
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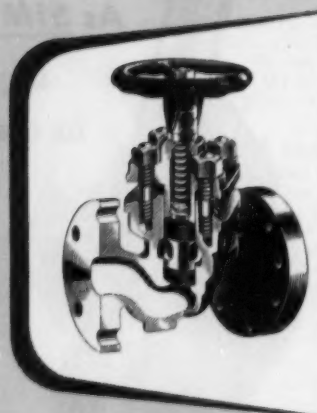

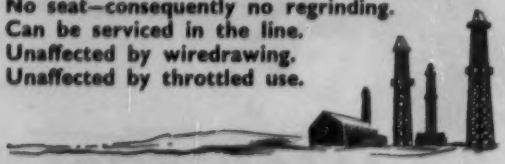

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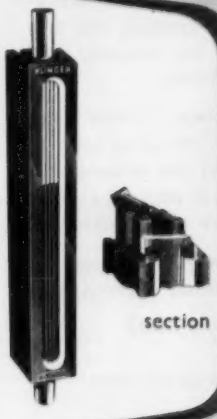

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The "K" Type Reflex Level Gage has the following outstanding advantages:-

Single row of tightening bolts.
Body free from distortion.
Glass easily removed.
Gage body turnable, free to expand, and easily removed.

KLINGER SLEEVE-PACKED COCKS

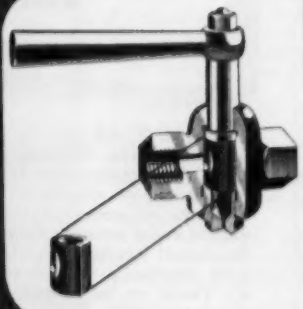
In the last quarter of a century Klinger Sleeve-Packed Cocks have steadily replaced the old-fashioned asbestos-packed cocks with their limitations of working pressures, difficulty of repacking and tendency to jam. They are available in a wide range of designs and sizes for all purposes and pressures, and with the following advantages:-

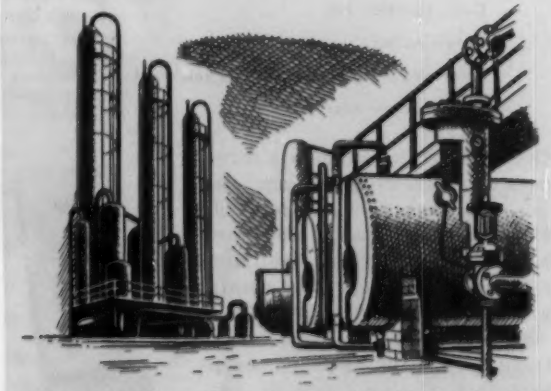
Renewable "Klingerit" packing sleeve.

Retightening during use.

Parallel-ground non-jam plug.

Unobstructed straight-thru full-bore passage.





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Reviewing New Books . . .

Chemical Engineering Cost Estimation, by Robert S. Aries and Robert D. Newton. This book is a practical treatment for chemical engineers, chemists, accountants, market researchers and other executives in the industry who are concerned with estimating costs of new units or plants as well as costs of manufacturing.

The book is geared to aid management in extracting from project reports the necessary information to prepare an economic estimate. It also serves in helping the engineer or chemist bridge the gap between technical details of a project and the economic factors.

The approach is chiefly quantitative, to provide useful relationships for direct application to problems. The presentation deals with each of the components of investment, cost and profits, with their interrelations explained and their applications discussed.

(McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, $6.)

Research on Boron Polymers—Literature Survey, prepared by Rutgers University for Wright Air Development Center. First steps in an exploratory Air Force study of boron polymers are described in this literature survey undertaken as a preliminary to detailed laboratory study and experimentation.

The broad objective of this research was to isolate new hydrolytically-stable polymeric materials of exceptional fuel and oil resistance, high thermal and other properties. The most practical approach to the preparation of high-temperature polymers appeared to be through the use of boron compounds based on amide linkage. Recent study of alkylated phosphinoborines indicated that these are a promising field for further investigation.

(Office of Technical Services, Department of Commerce, Washington 25, D. C., 58 pages, $1.50, order PB 111689.)

General Density Equation for Glyceridic Oil-Solvent Mixtures, prepared by the Department of Agriculture. A development that can be a great time- and work-saver for engineers engaged in the design or operation of plants for the solvent extraction of oils is reported in this government publication. This development is a simple quadratic equation by which the density or composition of binary mixtures of any glyceridic oil with any solvent can be calculated quickly and accurately.

The equation is applicable to densities of vegetable, animal, and marine oils. It can be used to provide information on density as a basis for accurate calculations of heat transfer and fluid flow in plant design. It is also useful for rapid determination of miscella concentrations at various stages of oilseed- and oil-processing. Validity and general applicability of the equation have been established on the basis of complete density-composition-temperature data for 21 binary oil solvent systems involving 9 solvents and 13 glyceridic oils.

(U. S. Department of Agriculture, Southern Regional Research Laboratory, 2100 Robert E. Lee Blvd., New Orleans 19, free of charge.)

Handbook of Hydrocarbon, by S. W. Ferris. This book gives a tabulation of the normal boiling points of hydrocarbons in the range of from -162 to 675C. In all, there are four tables which make the investigation of hydrocarbon boiling points an easy feat.

One table contains a list of the hydrocarbons in the order of their boiling point at 760 mm Hg. This does away with the usual hardship imposed by having the information tabulated by homologous series. The hydrocarbons are relisted in a second table in order of the number of carbon and hydrogen atoms in the molecule.

This comprehensive compilation includes data up to the early part of 1954. Common and trivial names of hydrocarbons also are given to make the information in this handbook readily available.

(Academic Press Inc., 125 East 23rd Street, New York 10, 324 pages, $8.50)

Development of High-Temperature Oil-Resistant Rubber, prepared by Battelle Memorial Institute. Research toward the development of a rubber compound which will withstand long-continued contact with ester-type lubricants at 350F and hydraulic fluids up to 550F is described in this report prepared for Wright Air Development Center.

This report includes sketches of an aluminum-block heating unit and other equipment constructed for these tests, a list of materials studied, their composition and sources, and 47 tables detailing the results of each experiment.

(Office of Technical Services, Department of Commerce, Washington 25, D. C., $3.50.)

Process Engineering Economics, by Herbert E. Schweyer. This new work is both a text and a reference book for students, as well as a reference for practicing engineers and other personnel in the process industries. For engineers, it is a source book of ideas for savings in design and operation, presented in the terminology and form familiar to management.

For students, it provides composite coverage of the theoretical enginering economy; accounting and financial data, including cost estimates and evaluations of the economic feasibility of operations, and cost balance to determine the optimum range of operations at the lowest cost.

(McGraw-Hill Book Company, 330 West 42nd Street, New York, $7.50.)

New Methods in Analytical Chemistry, by Ronald Belcher and Cecil L. Wilson. Compiled in this reference volume is group of analytical methods that have been either only recently discovered or have been hidden in the literature of analytical chemistry.

Many of the methods described have been tested under various conditions by the authors themselves; others were recommended by investigators in chemistry. All are based on classical, rather than instrumental, techniques. This volume shows them assembled for the first time in book form.

(Reinhold Publishing Corporation, 430 Park Avenue, New York 22, 276 pages, $5.50.)

Synthetic Rubber, prepared by the ASC Division of Rubber Chemistry. This book offers rubber chemists and technologists, as well as others interested in polymers and research chemistry in general, an exhaustive and authoritative account of synthetic rubber. It treats the development of synthetic-rubber manufacture in the U. S. and Canada during the last 15 years, when production rose from a mere 2500 tons in 1941 to a peak of 900,000 ten years later.

Reflecting the combined thought of 37 top-ranking industrial and academic specialists—most of whom were intimately connected with the government-sponsored programs from 1941 onward—the book reviews the great volume of research that has been carried on since the beginning of World War II. From first hand information, the authors discuss in detail the manufacture of the necessary raw materials; their conversion into synthetic rubber, and the industrial utilization of the product. Authoritative and extensively referenced, the book fills a pressing need in the literature of synthetics.

(John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, 1044 pages, $18.)

Synthetic Diene Elastomers Prepared at High Temperatures, prepared by Battelle Memorial Institute. This report, prepared for the Army Quartermaster Corps, covers research into the effects of high-temperature emulsion polymerization on the oil resistance and low-temperature properties of butadiene elastomers.

Some emulsion-polymerization recipes previously considered impractical were successfully tested and found controllable and reproducible. Comparative tests of butadiene-acrylonitrile elastomers and copolymers prepared at 50, 90 and 120C showed that oil and heat resistance were improved by preparation at higher temperatures, though there was some reduction of tensile properties at 120 C.

Oil-resistant elastomers were prepared which showed an outstanding balance of oil resistance and low-temperature properties.

(Office of Technical Services, Department of Commerce, Washington 25, D. C., $1.50.)

Vulcanization of Rubber with High-Intensity Gamma Radiation, prepared by Wright Air Development Center. High-intensity gamma radiation of rubber, a new vulcanization technique, has produced elastomers with markedly better resistance to dry heat and oil aging than chemically-vulcanized compounds. Many experimental polymers which resist chemical vulcanization may be readily vulcanized by this process.

Through this Air Force study it was found that uncured vulcanizable elastomers may be cross-linked without chemical vulcanizing agents and high curing temperatures. The elastomers are uniformly vulcanized by the penetrating power of high-energy gamma rays.

No residual radioactivity is imparted to the elastomer, and maintenance problems, with proper shielding, are comparatively simple. The unique physical and functional properties of elastomers prepared by this process are described, and compounding formulae and test data are shown in tables.

(Office of Technical Services, Department of Commerce, Washington, 25, D. C., 37 pages, $1, order PB 111675.)

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 12 cents per word. Minimum charge, $3. Blind box address in our care counts six words. Replies forwarded without charge. Situation wanted ads, 6 cents per word. Display ads, set in suitably larger type with ruled border, $12 per column inch; situations wanted display ads, $6 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

PROFESSIONAL SERVICES

• HIGH voltage electrodeless discharge is on its way as one of the new tools in petroleum refining. High voltage discharge eliminates sludge formation! High voltage discharge removes gases and water! High voltage discharge improves high temperature greases! High voltage discharge makes lubricants from non-lubricants! Let us describe the use of this new tool. No obligation, of course. Research and Development Corporation, 21 East Van Buren Street, Chicago 5, Illinois.

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WANTED: One Piping Estimator
One General Construction Estimator

Apply to Kaminer Construction Corporation, P. O. Box 227, Chamblee, Georgia. Need piping estimator capable of complete takeoff and handling of jobs involving paper mill, chemical plant, power plant and general industrial piping. Also general construction estimator to handle industrial buildings, as well as all types general construction occuring in above types of work. We are moving our headquarters from Greenville, South Carolina to greater Atlanta. Salaries open.

Plant Equipment Inspectors

Senior Inspectors for company operation in Saudi Arabia and company engineering department in The Hague, Holland. Should be graduate engineers with minimum 8 years' experience in design or inspection of petroleum processing plants and equipment, 5 years' actual inspection experience necessary.

In Saudi Arabia—will advise operating department on code and equipment limitations, develop inspection methods, supervise and conduct inspections.

In The Hague—will inspect and approve equipment and material purchases, advise and assist foreign manufacturers to comply with U.S. Standards and Specifications.

Salary commensurate with education and work experience. Write giving full particulars regarding personal history and work experience.

Recruiting Supervisor, Box 73

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

HELP WANTED

AREA ENGINEERS

Several graduate engineers with minimum 5 years' experience supervising maintenance engineering functions in oil refining or producing facilities, power plants, heavy industrial installations, manufacturing plants, or related operations. To establish technical supervision, procedures, maintenance operations and schedule routine and special work for major oil producing and refining operation with all supporting facilities; i.e., housing, feeding, recreation, etc.

Salary commensurate with background and experience. Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 83

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

ENGINEERS

Chemical & Mechanical

0 TO 3 YEARS EXPERIENCE

OPPORTUNITIES IN DEVELOPMENT, PROCESS ENGINEERING OR DESIGN ENGINEERING

When planning your career, you'll want to find an organization in which to fully use your engineering training and ability . . . one which encourages your advancement . . . and one which can provide a good measure of job stability in the years to come.

The M. W. Kellogg Co. is a leader in engineering design and construction of oil refineries and chemical plants the world over. Young engineers in our employ are assisted financially to continue their graduate work in the evenings. There is also a full time scholarship program. If you would like a permanent, satisfying engineering career, send your resume today to Mr. R. L. Stacom. Interviews will be arranged promptly for qualified applicants.

THE M. W. KELLOGG CO.
225 Broadway New York 7, N. Y.

HELP WANTED

• PROCESS ENGINEER—Engineering graduate experienced in the process design of various types of petroleum refining process units required by a midwestern engineering and construction firm. Please submit resume and photograph indicating education, experience and salary requirements to Box 210-R, c/o Petroleum Refiner, Houston, Texas.

CHEMICAL ENGINEER

Houston refinery has opening for graduate Chemical Engineer with minimum two years actual engineering experience in Petroleum refinery. Salary open.

Send complete resume to P. O. Box 5008 Harrisburg Station, Houston 12, Texas

MECHANICAL ENGINEER WANTED

An excellent opportunity is afforded a mechanical engineer with proper qualifications by a southwestern glass company manufacturing glass containers. Glass-house experience desirable but not absolutely necessary. Experience in electrical, ceramic, industrial or chemical engineering also would be helpful. In reply, please give age, family status, complete experience, compensation desired, recent photo or snapshot, etc. Reply to: Box 214-R, PETROLEUM REFINER, Houston, Texas.

PROCESS DESIGN ENGINEER

If you have a degree in chemical engineering and 5 to 10 years of diversified process design experience in petroleum and chemical industries, and are interested in a process design position with a future, you should consider joining the McKee organization.

Please send complete personal details including salary requirements to:

Edward A. Kolner
ARTHUR G. McKEE & COMPANY
2300 Chester Avenue
CLEVELAND 1, OHIO

CHEMICAL ENGINEERS

Graduates with minimum 3 years' process design experience in oil refinery or surface oil producing facilities. For New York office. Must, however, be willing to relocate in foreign operation at some future date.

Also Chemical, Mechanical and Electrical Engineers with comparable or related experience are needed for process and project work in Arabia. Assignments and salary commensurate with experience and training.

Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 23

Arabian American Oil Co.
505 Park Avenue
New York 22, New York

HELP WANTED

Mechanical Engineers

(AGES 28-40)

Desired for career opportunities with a major integrated oil company operating in South America. Position vacancies exist for graduate mechanical engineers at levels requiring five to fifteen years of mechanical engineering experience. Activities include design, installation and modification of compressors, turbines, hoists, pressure vessels, automatic controls, air, gas, steam and water distribution systems, centrifugal pumps, etc. Excellent growth opportunities in an expanding organization. Salary, including bonus, $12,500-$19,000, depending on qualifications and experience. Liberal employee benefits, home vacations with travel expenses and tax savings. Send complete resume of education, personal data and work experience. Interviews will be arranged for candidates whose resumes indicates potentiality. Replies held in strictest confidence.

Box 1221
Dept. T-14
New York 1, N. Y.

Equipment Inspectors

(AGES 25-32)

Career opportunities with a major integrated oil company operating in South America. Vacancies exist in refinery equipment inspection positions at levels requiring two to five years inspection experience. Candidates must be graduate engineers with a degree in engineering, preferably mechanical or metallurgical engineering. Salary, including bonus, $11,000-$12,500, depending on qualifications and experience. Liberal employee benefits, home vacations with travel expenses and tax savings. Send complete resume of education, personal data and work experience. Interviews will be arranged for candidates whose resumes indicate potentiality. Replies held in strict confidence.

Box 1221
Dept. Q-14
New York 1, N. Y.

REFINERY or PROCESS PLANT SUPERINTENDENT

Excellent opportunity for man thoroughly versed in instrumentation, controls and steam process piping, and with background in Houdray process, hydrogen regeneration, cracking and catalytic units. Requires man capable of supervision operation of multi-million dollar ram jet facility. Salary $10,000. Many benefits, fine residential communities in area. Send complete resume to Mr. R. T. Hunt.

WRIGHT AERONAUTICAL DIVISION,
Curtiss-Wright Corporation

Main and Passaic Streets • Wood-Ridge, N.J.

* * *

REFINER

Classified Ads

Don't Cost . . .

They Pay

* * *

Suppliers . . .

Rochester Manufacturing Company has elected **Robert W. Morgan** as vice president in charge of engineering. He will be in charge of design and research. He was formerly vice president of engineering for the Fedders-Quigan Corporation.

The Pfaudler Company has made two new additions to the staff of its Engineering department. **John W. Cosier** will assume the duties as engineer in charge of the newly formed Applications Engineering section, and **James D. Ross, Jr.,** becomes engineer in charge of the Project Engineering section.

Prior to his new assignment, Cosier had been working in the Project Engineering group at Pfaudler's Rochester division. Formerly with Jefferson Chemical Co., he is a graduate of Rensselaer Polytechnic Institute. Ross had been working in Project Engineering before becoming head of that section. He came to Pfaudler from Phillips Petroleum. Earlier experience was with Lummus Co., and Lukens Steel Co. He attended Cornell University.

The Dow Chemical Company elevated its New Orleans office to full sales-office rank, and **Robert J. Minbiole** has been appointed as manager. Established in January, 1955, the office has operated as a branch of the company's St. Louis office. It will continue to service markets in Louisiana, the southern half of Mississippi, southwestern Alabama and northwestern Florida. Minbiole, who joined Dow in 1940, has served since 1944 as manager of film and sheeting sales for the company's Plastics department.

ALCO Products, Inc., has appointed **Everett N. Sieder** as marketing-manager of thermal products. He will be responsible for the sale of equipment for the processing and other industries.

He joined ALCO in 1946 as a sales engineer and was named manager of the company's refinery sales in 1947. In 1948 Sieder was appointed manager of the New York sales district for thermal products, and was transferred to Dunkirk, N. Y. as assistant manager of sales engineering in 1951. He was made manager of thermal product planning, the position he held until his recent appointment, in 1954. Prior to joining ALCO Sieder was employed by the Foster Wheeler Corporation.

Deaths—

Robert S. Haff, with Norton Company, recently died. With the company since 1951, he was assigned to the Refractories Sales Engineering department. He was 39-years-old.

Blaine S. Smith, retired president of Universal Atlas Cement Company, died October 27 at New Rochelle, N. Y. He had been associated for more than 37 years with the cement company.

Kenneth R. Farr, vice-president of Petrolite Corporation and general manager and sales manager of the Tretolite Company division, died October 3 at St. Louis, Mo. His death resulted from a heart attack.

For more data on advertised products, use Readers' Service Cards, last page.

ORBIT VALVES®

For HYDROCARBONS
LIQUIDS
GASES

NATURAL GAS
ETHANE
PROPANE
BUTANE
ETHYLENE
PROPYLENE
BUTADIENE
HYDROGEN
NITROGEN
AMMONIA
BENZENE
TOLUENE
XYLENE
AIR

POSITIVE, LEAK-PROOF SHUT-OFF

Orbit's principle of closure by compression is the most desirable and practical method of shut-off known. Closure by compression gives these advantages: Elimination of friction that in turn reduces wear which in return reduces frequency of repairs — a chain reaction that results in savings over the long haul to you.

See 22nd Edition of Refinery Catalog for full particulars on Orbit Forged Steel ASA Class valves or write for Catalog 55-B. A good range of sizes are available beginning with 1".

BRANCHES

HOUSTON, TEXAS
407 Velasco
(Serving the Gulf Coast)

CASPER, WYOMING
247 West First Street
(Serving the Rocky Mountain States and Canada)

ODESSA, TEXAS
402 West County Road
(Serving West Texas)

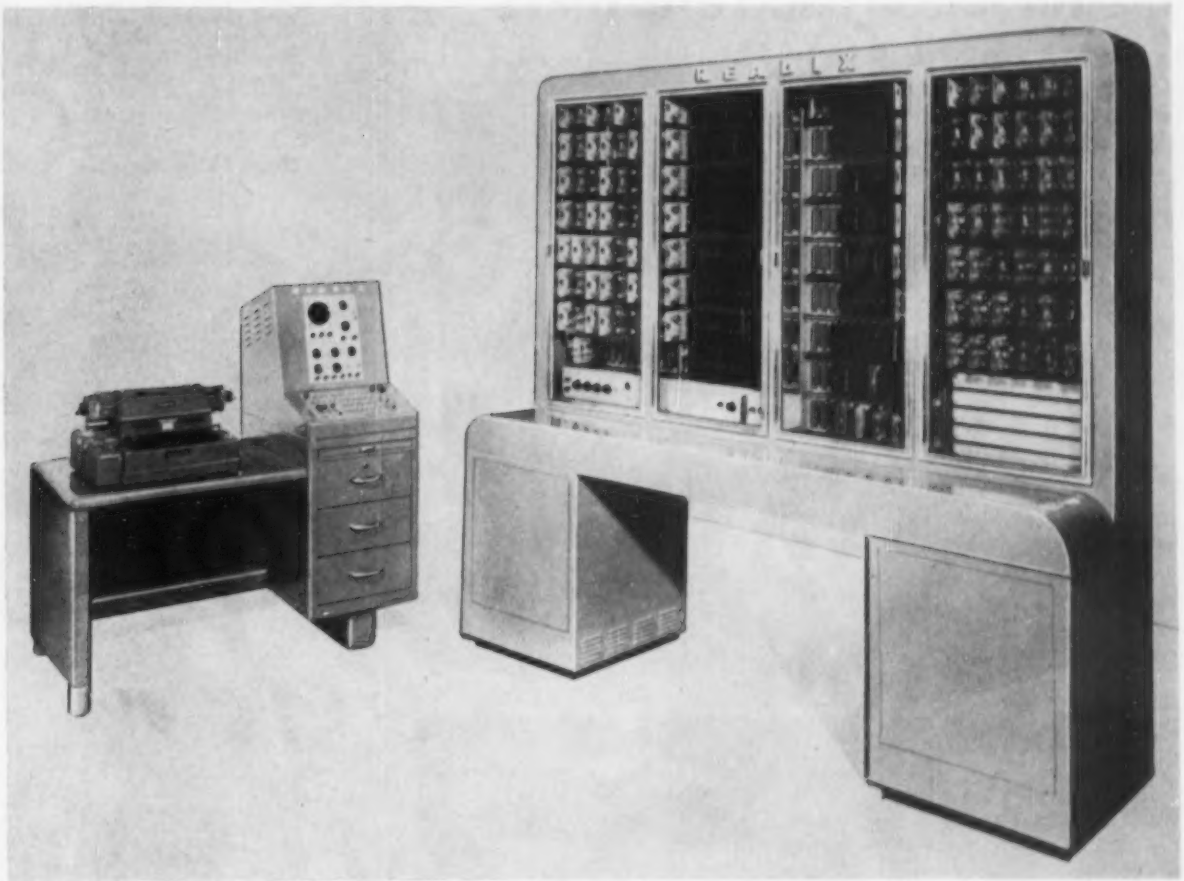
(For over 40 years)

ORBIT VALVE COMPANY

P. O. BOX 699 **TULSA, OKLAHOMA**

For more data on advertised products, use Readers' Service Cards, last page.

What's New In Equipment . . .



Here's a New Computer For Plant Automation

The Readix, a medium-speed, low-cost computer designed to meet the varied requirements of industrial control-data reduction, record keeping, business-data processing, and scientific computation, is being manufactured by the J. B. Rea Company, Inc., of Santa Montica, Calif. The unit is intended to fill the need for low-cost computing services among many industrial and business organizations which are not justified in the extensive investment required for large high-speed computers.

The physical design of the READIX class of computers is intended to keep maintenance problems to a minimum. A test panel arrangement is provided which permits a competent technician, trained in the basic operation of digital computers, to efficiently maintain the unit. The expense of maintaining full time highly trained maintenance engineers is thus minimized.

Other cost reducing features include a number of special operating features and an unusually complete set of commands which greatly speed the work of the programmer. More work can thereby be programmed through the computer with resulting lower overall costs. An automatic floating decimal point operation which speeds up programming procedure by reducing the number of commands the computer must follow to complete a given problem or routine operation is one of the important features.

The unit can be adapted to data handling equipment already in use in many organizations. Instructions and data can be fed into the unit by means of electric typewriters, punched paper tape or magnetic tape, or through IBM cards, or through punched cards, which it will accept at the rate of 100 cards a minute.

Output data can be reproduced in several forms, including typed copy or punched paper tape or electric typewriters at the rate of 10 characters per second; punched cards at the rate of 100 cards per minute, or on magnetic tape.

Where management report charts are needed the unit will transpose it's computed results onto plotted charts or graphs, which it draws at the rate of one point per second. In industrial applications the output whether in the form of punched tape, magnetic tape, or punched cards, can be used to operate automatic production equipment and process control equipment. In this way, the unit will calculate the data required to control a process, then record the results in a choice of three media that can be used to operate the control equipment involved.

The unit will continue computing during this output cycle, and can be programmed for automatic tabulation of output data. Rea Company engineers specialize in design and construction of special data handling equipment to be used with the computer where existing equipment will

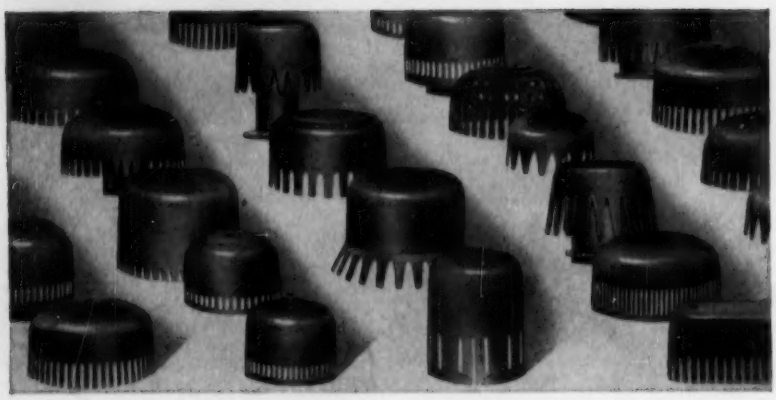
RUGGED H_2 INDICATOR
for catalytic reformers

Works on a simple, mechanical principle using specific gravity to measure H_2 in reformer recycle gas. Low cost. Instant response. Local or remote readings. Replaces expensive, delicate instruments that "can't take it."

Other uses: Measuring specific gravity of refinery fuel gas, off-gases from cracking furnaces, demethanizers, etc. and for gas blending . . . also analyzing boiler and heater flue gases to cut fuel costs.

For details write to The Permutit Company, Dept. PR-11, 330 West 42nd St., New York 36, New York.

RANAREX®



SEND FOR PSC
BUBBLE CAP BULLETIN 22

Largest Compilation of Engineering Data.

Lists 300 Styles Furnished Without Die Cost.

This standard reference on bubble caps and risers contains complete specification information for hundreds of variations. Also many drawings for use in determining methods of tray assembly. With dies on hand for all listed styles, PSC can save you substantial die costs as well as design and delivery time. Furnished in any drawing type of metal, to meet your coking or corrosion problems. Assemblies will also be produced to your specifications.

THE PRESSED STEEL CO., 715 N. Penna. Ave., Wilkes-Barre, Pa.

PSC

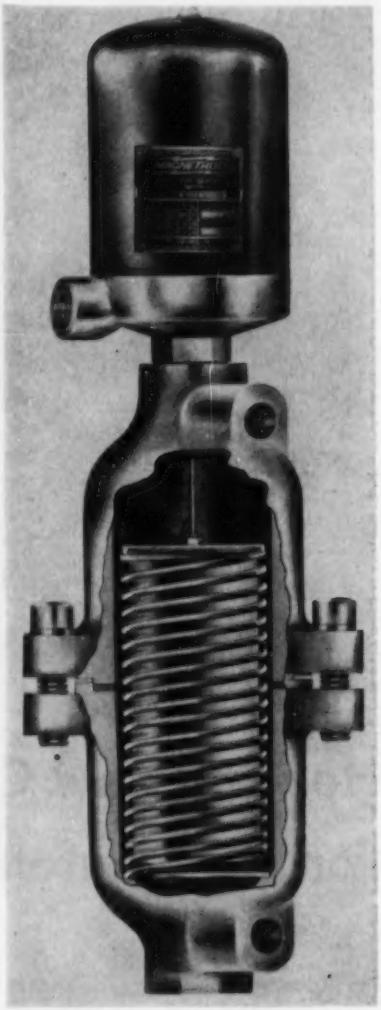
Custom Fabricators for the Process Industries Since 1928. Send Your Blue Prints.

New Equipment . . .

not meet the requirements of the job to be performed.

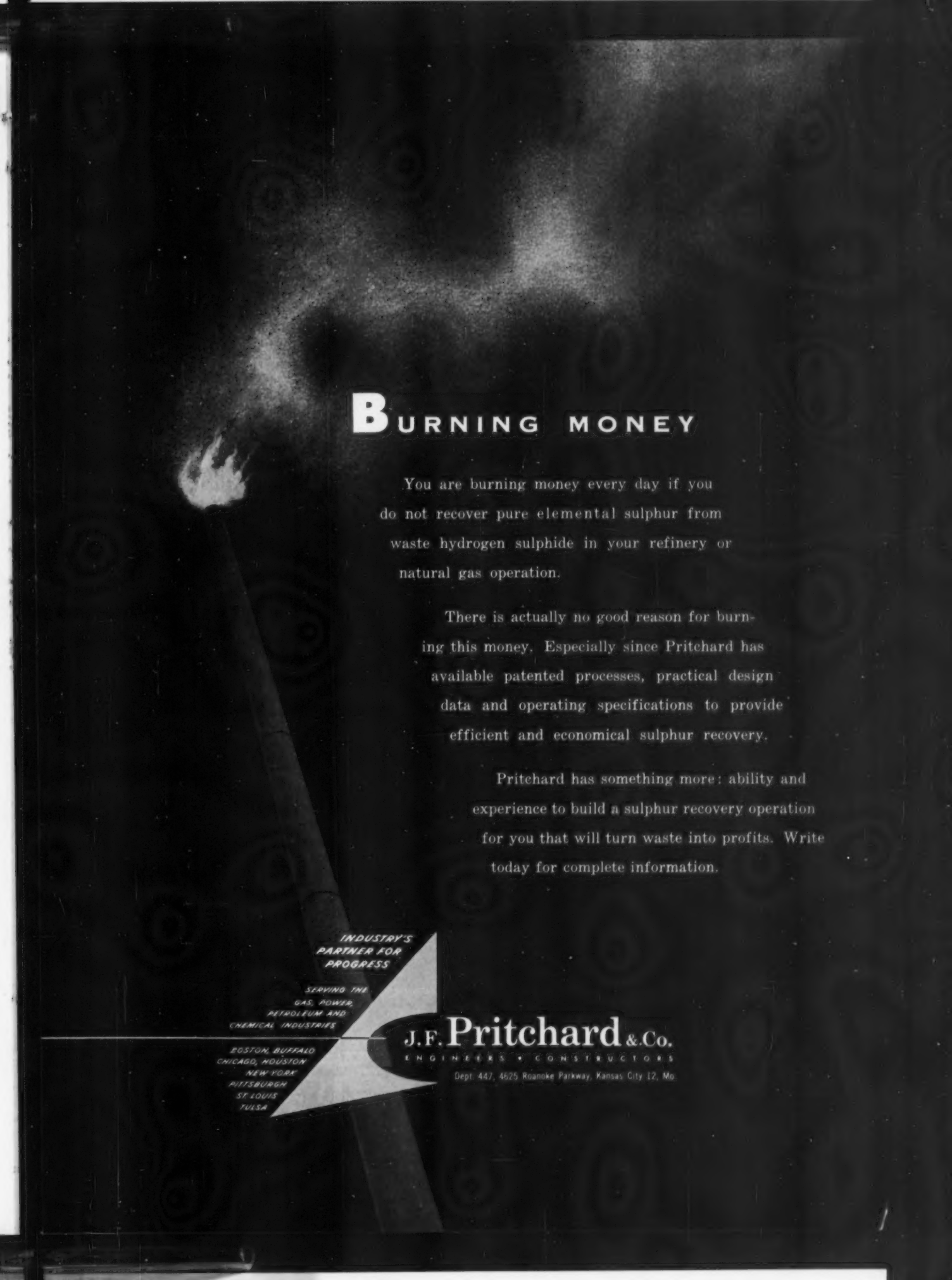
A 12-page brochure describing the READIX and it's operations is available and the manufacturer will provide special information on applications for the computer or other control system problems. For further information that may be of use to you, just

Circle E1 on Postcard



Liquid Level Control for single level stage has been introduced by Magnetrol Inc., Chicago, in a new displacement type.

This new control makes use of the basic principle of buoyancy obtained by displacement by a solid immersed in a liquid. A solid block displacer of glazed porcelain or Karbate "loads" its weight on a compression support spring. Raising liquid level imparts buoyancy to the displacer in proportion to the weight of the liquid it displaces to "unload" the spring and upon further rise, to produce the desired switch action. The Model A-1501 is designed for pressures of 1500 psi. The Model A-3001


BURNING MONEY
You are burning money every day if you do not recover pure elemental sulphur from waste hydrogen sulphide in your refinery or natural gas operation.
There is actually no good reason for burning this money. Especially since Pritchard has available patented processes, practical design data and operating specifications to provide efficient and economical sulphur recovery.
Pritchard has something more: ability and experience to build a sulphur recovery operation for you that will turn waste into profits. Write today for complete information.
INDUSTRY'S PARTNER FOR PROGRESS
SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES
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ENGINEERS • CONSTRUCTORS
Dept. 447, 4625 Roanoke Parkway, Kansas City 12, Mo.

the valve that LIKES TO BE COMPARED

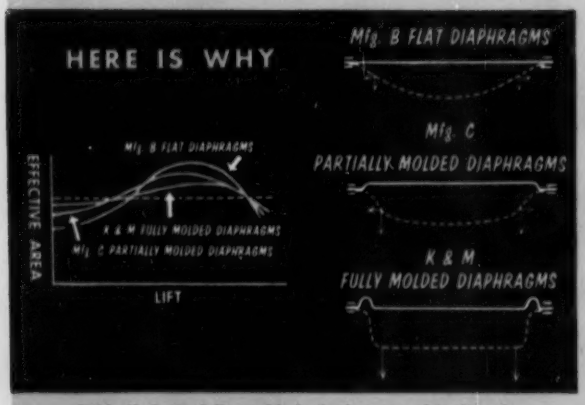
K & M provides 20-40% less positioning error. Often the need for a valve positioner is eliminated . . . because the K & M *fully* molded diaphragm gives the most constant effective diaphragm area.

K & M precision positioning also derives from long stem travel . . . lift that equals or exceeds any comparable valve . . . plus the highest power factor in the industry.

Behind it all lies one fact: K & M Control Valves are not *adapted* to high lift, they are *designed* for it. Throughout the entire range of valve travel . . . positioning is accurate and undistorted . . . control increments are finer with minimized positioning error.

Write for the K & M Valve Data Catalog, Bulletin CV-53.

77th Anniversary . . . Oldest U. S. Pressure and Level Control Valve Manufacturer



With K & M *fully molded* diaphragms, virtually all components of force are vertical. Added to this, K & M gives the highest power factor (diaphragm area x lift) for precise valve positioning.

diaphragm control valves

KIELEY & MUELLER, INC.
64 GENUNG STREET, MIDDLETOWN, NEW YORK

K&M

New Equipment . . .

is designed for pressures up to 3000 psi. The Model A-5001 is designed for pressures up to 5000 psi.

Each of these controls may be used for either high or low level service. The control is designed to operate with liquids having a specific gravity of .40 or above. Chambers are of cast steel of flanged design and in thickness to suit the pressure requirements of the application. Spiral wound asbestos or ring steel gaskets. Heat-treated, high alloy steel allen-head flange bolts. Displacer of glazed porcelain or Karbate where required. Type 316 stainless steel compression spring for use where corrosion is a factor. Inconel compression spring for temperatures up to 300° F.

Also available in this particular line of level controls are special purpose "anti-vibration" mercury switches for such service conditions. To get full details just . . .

This item supplements Magnetrol Inc. data on pages 557-560 of The Refinery Catalog, 22nd Edition.

Circle E2 on Postcard

Ultrasonic Flow Meter . . . Fischer and Porter Company will manufacture and sell for industrial applications under license from The W. L. Maxson Corporation an ultrasonic flow meter. The unit has no moving parts and no obstructions to fluid flow; consequently it offers virtually no pressure drip or clogging. Flow rate is measured by electro-acoustical means. Controlled pulses of ultrasonic energy are sent across the pipe section and the rate at which the pulses reach the other side, proportional to the flow rate, is translated into electrical signals.

The device can be used with equal facility to measure volume flow or mass flow since a unique ultrasonic sensing element determines the instantaneous density. It is unaffected by electrical conductivity of the fluid or by light concentrations of dispersed solids. for further information, just . . .

Circle E3 on Postcard

A rugged new solenoid valve which uses a spring-loaded synthetic valve and introduces other new features to assure more positive seal-off is announced by Minneapolis-Honeywell Regulator Company.

The soft-seat valve, made of Buna N rubber, is designed to help reduce the possibility of leakage caused by foreign par-

Increases output of "OXO" plant 25% with GIRDLER G-29 CATALYST

at Gulf Oil Corporation
Port Arthur, Texas

APPLICATION: Production of hydrogen and carbon monoxide synthesis gas for OXO process. End product: aldehydes and alcohols from olefinic hydrocarbons.

TECHNICAL SERVICE: Girdler catalyst engineers studied application and suggested the new G-29 for greater throughput. (Formerly used another Girdler catalyst.)

RESULTS: Increased production of the ratio gas 25%.

Girdler Catalyst Technical Service is available to help improve *your* processing. Call us, or write for Bulletin G 260.

HOW YOU BENEFIT WITH GIRDLER CATALYSTS

The **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION: New York, San Francisco
VOTATOR DIVISION: New York, Atlanta, Chicago, San Francisco
In Canada: Girdler Corporation of Canada Limited, Toronto

For more data on advertised products, use Readers' Service Cards, last page.

INSTALL
peak performance
INTO YOUR
compressors
(AIR • GAS • AMMONIA)

Peak performance, maximum efficiency, greater output, and lower power costs can be built into your oldest, and of course your newest, compressors by the installation of VOSS VALVES.

Check THESE VOSS VALVE ADVANTAGES:

- Quiet, vibration-free operation
- 20 to 60% more valve area
- less power consumption
- minimum pressure loss
- normal discharge temperature
- lower operating costs
- utmost safety

Our detailed proposal for increasing the efficiency of your compressor will be sent you without obligation. Send us the name, bore, stroke, and speed of your machine.

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Reprints available

How to Get Those Top Octanes

by Marshall Sittig and Wayne Warren

This 51-page report on octane improvement techniques includes the most authoritative comparison of catalytic reforming today. But catalytic reforming is not the only way to get top octanes. In this report you will have ready reference to these other techniques:

- Isomerization
- TEL Addition
- Polymerization
- Alkylation
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Now available in one source for $1.00

Write:

Reprint Department, Petroleum REFINER,

P. O. Box 2608, Houston 1, Texas

New Equipment . . .

ticles which may lodge in the metal seat. Other improvements include:

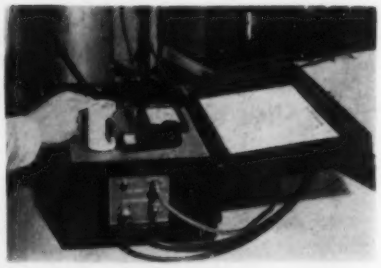
- Replaceable coils
- Conical Spring-loaded plunger
- Easy, foolproof installation

Available models are in ¾-inch, ½-inch standard and large and ⅜-inch sizes. Two different types for low voltage or line voltage operation are also available.

Complete details are available on this new line of solenoid valves now.

Circle E4 on Postcard

This item supplements the Micro Switch, a Division of Minneapolis-Honeywell Regulator Company, data on page 586 of The Refinery Catalog, 22nd Edition.



Dewpoint Indicator . . . A new portable manually-operated dewpoint indicator for easy, convenient measurement of moisture in gases has been announced by General Electric Company's Instrument department. The unit is designed for applications where only periodic checks of dewpoint are desired. The indicator determines the moisture content of a gas by measuring the temperature at which the moisture begins to condense. This is done by cooling a mirror surface and observing the temperature at which dew first forms.

The indicator gives accurate readings over a range of dewpoint temperatures from ambient to —100 F. (0.0003 percent moisture by volume in air). The instrument requires no electrical outlet, operating on self-contained battery, and can be used to measure different gases in rapid succession. It weighs 16 pounds. For additional information, just . . .

Circle E5 on Postcard

This item supplements General Electric Company data on pages 442-443 of The Refinery Catalog, 22nd Edition.

Metallic Clad Thermocoupled Wire . . . Thermo Electric Company, Inc., has announced its new "Ceramo" thermocouple and thermocouple extension wires. These ceramic insulated, metallic clad wires are extremely small in diameter, very rugged and readily formed. They are made in a variety of thermocouple materials, in several gages and outside diameters, and in different types of seamless metal tubing overall.

Thermocouple wires are made in lengths up to 30 feet and the extension wires in varying lengths up to 2000 feet. All of them are made to standard ISA calibration accuracies.

To further increase the life of the conductors, tubes are made of various metals

CENTRIFUGAL SYNTHESIS GAS CIRCULATORS

GHH Maulwurf pumps are high pressure centrifugal gas circulators especially designed for application in the chemical industry to increase the pressure of the nitrogen-hydrogen mixture in ammonia synthesis.

COMPRESSORS **PRESSURE VESSELS**
BLOWERS **HEAT EXCHANGERS**
EXPANDERS **COLUMNS**

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KLEMP **HEXTEEL** ▶

Hexteel is an armor and retainer for castable refractory monolithiclinings used for cat crackers, reactors, regenerators, fractionators, heaters, strippers, risers, stacks, cyclones, ducts, breeching, furnaces and tanks.

and FLOORSTEEL ▶

Floorsteel is an armor and retainer for monolithic liners applicable to small diameters for pipe linings, heads, plenum chambers, sumps, stacks and furnaces.

Hexteel and Floorsteel carbon or stainless steel armors and retainers prolong the life of vessel liners by resisting abrasion and corrosion. Our engineering department is prepared to design your total lining requirements. Whatever the destination, we will deliver your Hexteel or Floorsteel world-wide in record time!

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Chicago 38, Illinois

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6601 South Melvina Avenue, Chicago 38, Ill.

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Kindly send me a copy of your "Data and Specification Manual."

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Firm_____
Address_____
City_____ Zone_____ State_____
Phone_____

When **HEAT** or **CORROSION** Add to Your Pressure Piping Problems . . .

Protect Pipe Joints with . . .

WATSON-STILLMAN FORGED STAINLESS or ALLOY STEEL FITTINGS

IN CORROSIVE SERVICE your pipe joints take a beating—fluid velocity and turbulence accelerate corrosion wherever there is a change in direction of flow.

AT HIGH TEMPERATURES structural changes in the metal can cause loss of strength and subsequent failure.

Those are good reasons for "playing it safe" in high pressure service with W-S Forged Stainless or Alloy Steel Pipe Fittings. W-S Stainless Fittings resist corrosion in a wide variety of process liquids and gases and high temperature steam. Available in Types 304, 316 and 304 L.

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W-S Forged Stainless and Alloy Steel Fittings can be obtained in Screw-End Type for 2,000 lb., 3,000 lb., and 6,000 lb. WOG service; Socket-Welding Type for Schedules 40, 80, 160 and Double-Extra Heavy Pipe. Send today for bulletin S-1-55.

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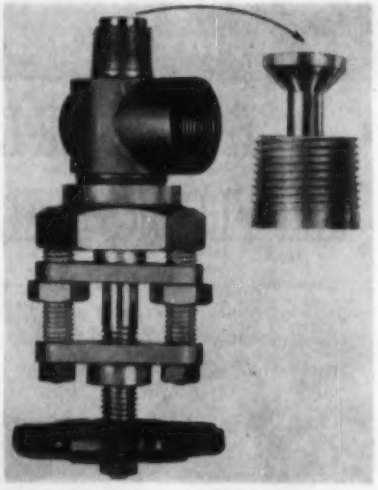
New Equipment . . .

depending on whether the application requires high resistance to moisture, chemicals, petroleum products, atomic radiation or abrasion. However, regardless of which one is used, the combination of magnesium-oxide insulation and metal tubing overall will have a temperature rating considerably higher than that of any previous standard insulation. For additional information . . .

Circle E6 on Postcard

Tractor Shovel . . . A new Michigan Model 75-A tractor shovel is shown being used in road construction at an oil refinery. The shovel is a highly versatile rubber-tired high lift type loader that lends itself to many sorts of plant maintenance activities. For information on this unit, just . . .

Circle E7 on Postcard



Drain Valve that is completely self-draining has been announced by Jerguson Gage and Valve Company. The valve is used for installations where it is desirable to have the valve seated inside the wall of the vessel to prevent liquid from remaining in the nipple and valve. This valve has outside screw and yoke construction to meet high temperature or corrosive conditions where inside threads cannot be tolerated. The outside thread design eliminates possible freezing and allows the valve stem

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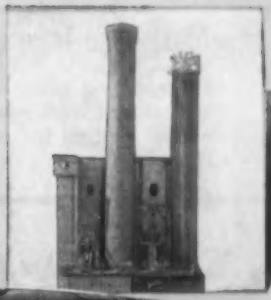

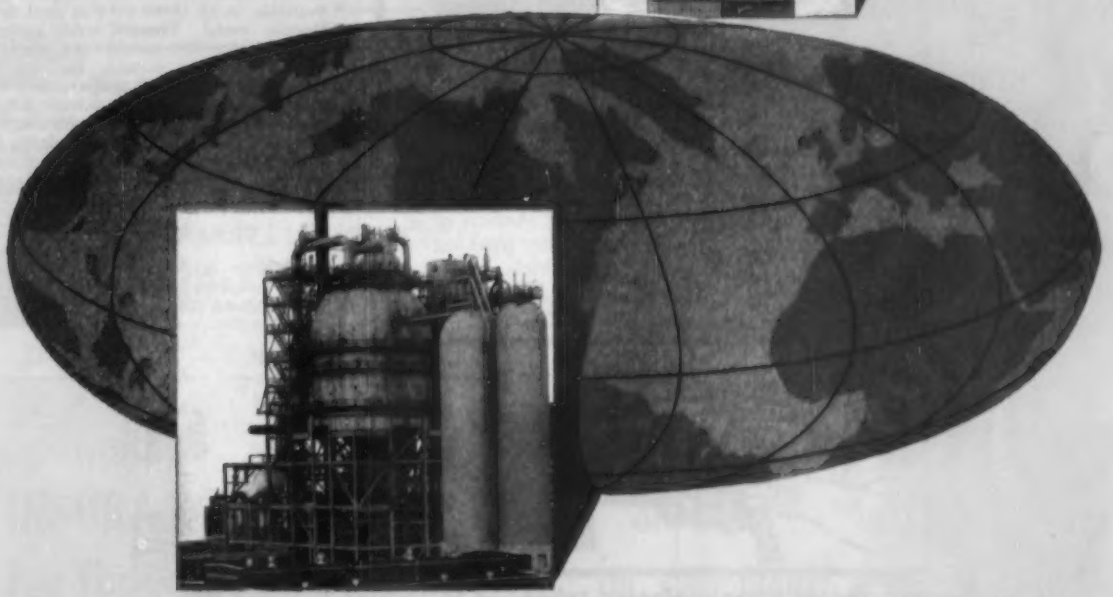

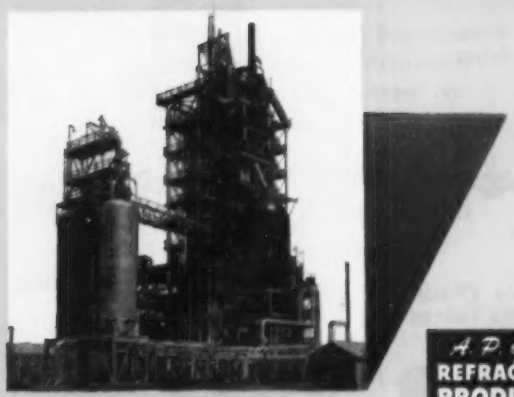

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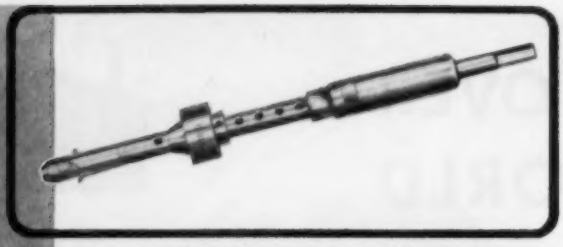
For more data on advertised products, use Readers' Service Cards, last page.

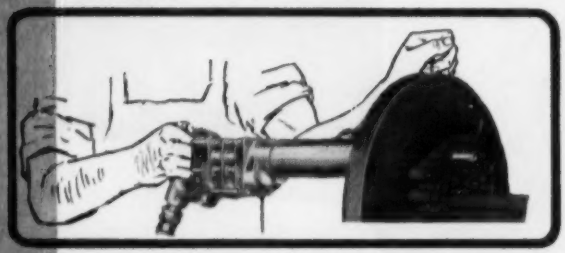


Now—a new push-type internal Tube Cutter

A time-saving maintenance tool that may be used with your present air or electric motor to cut non-ferrous tubes.

Easily carried. A must in every tool box.

Many uses in every plant. Action of cutting blades is produced by pushing cutter into the tube which automatically opens the double cutter blades.

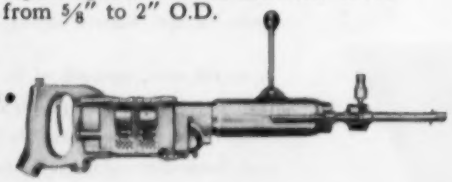


Works wonders when replacing tubes

Extremely useful. Saves time when replacing worn, small diameter tubes from ⅝" to 2" O.D.

Also furnished with motor and lever operator

An air-driven type internal tube cutter is available for production use. Cuts non-ferrous tubes 2-4 seconds each. Steel tubes 8-12 seconds each. Literature and complete details upon request.



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New Equipment . . .

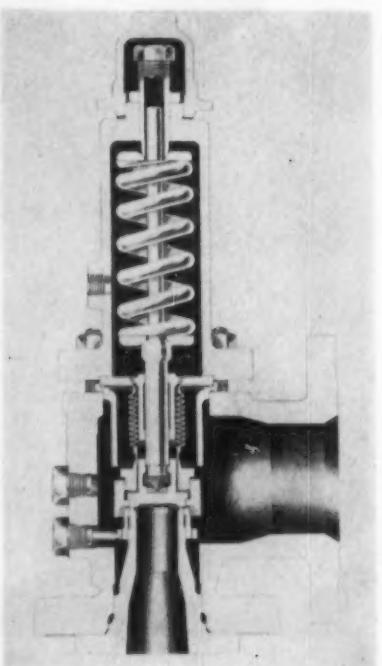
to work freely at all times. Recommended services pressures for this valve are up to 4000 pounds at 100 F. or 1000 pounds at 750 F. The standard valve is built with a ¾-inch N.P.T. Female Drain Connection. It weighs 4½ pounds. Standard materials of construction are carbon steel body, stainless steel stem, and Stellited seat. Optional materials include various special alloys to meet corrosive or other troublesome conditions. For complete details on this new tank valve . . .

Circle E8 on Postcard

Ball Joints For Piping . . . Barco Manufacturing Company, now offers a new design in 8-inch, 10-inch and 12-inch sizes. Flanged end and welding end patterns are available in all three sizes in steel or Bar-Ductile metal. Flanged end joints are rated 150 or 300 pound and joints with welded ends are suitable for 600 P.S.I. steam and operating temperatures up to 1000 F. These units are intended for use where tanks settling or expansion movement is encountered and thus piping strain may be avoided. Joints will permit angular flexure up to 15 degrees. For complete information . . .

Circle E9 on Postcard

This item supplements Barco Manufacturing Company data on pages 182-183 of The Refinery Catalog, 22nd Edition.



A Relief Valve which is designed primarily for use on services where protection against corrosion, fouling of working parts, and new low back pressure surges has been announced by Crosby Steam Gage & Valve Company. The Protecto-Seal Bellows Pro-

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all over your plant use Safety GRIP-STRUT

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the new basic material, all in one piece (including channels), not welded, riveted or expanded in steel or aluminum, in standard sizes and gauges. Safety GRIP-STRUT presents an open space, in a diamond pattern, in excess of 55% of the area for ready access of light and air and gives a positive NON-SKID footing in all directions. Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

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Flooring

Machine Guards

Balconies

Important Safety Features

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- ★ Easy to stand on
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New Equipment . . .

tector shields the bellows from adverse turbulent effects from the flowing media, preventing premature failure of the bellows due to fatigue.

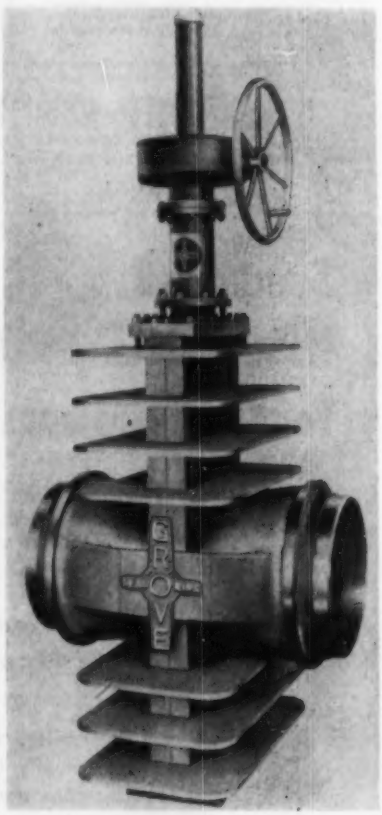
This protector also acts as a positive lift-stop preventing over-compression of the bellows. The two-ply bellows is so designed that the effective area of the valve seating surface is essentially balanced to nullify the effect of variable and constant back pressure on its performance. The valve has been tested for performance and flow at pressures from 25 psi to 2500 psi.

It is available in eleven orifice sizes and is interchangeable with the present line of Crosby Full Nozzle JO Relief Valves. It is furnished in 1-inch to 6-inch inlet sizes, in forged stainless steel full nozzle construction. Also the valve is available with internal heating coils and flushing coils where required.

For full data, just . . .

Circle E10 on Postcard

This item supplements Crosby Steam Gage & Valve Company data on Page 293 of The Refinery Catalog, 22nd Edition.



Steel Gate Valves with a fabricated body has been announced by Grove Valve and Regulator Company. The valve, called Grove Seal-"O"-Ring, is available in sizes up to 36-inch for petroleum and gas pipe line pressures. The unusual feature of this valve is its fabricated steel body design. It is a full opening or venturi type and is available with flanged or welding ends. The Grove through-conduit fabricated

For more data on advertised products, use Readers' Service Cards, last page.

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CRACKING CATALYST

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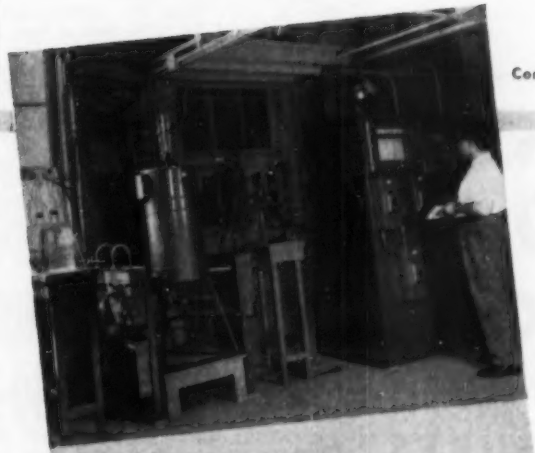
Nalcat **HA-1 or HA-2**



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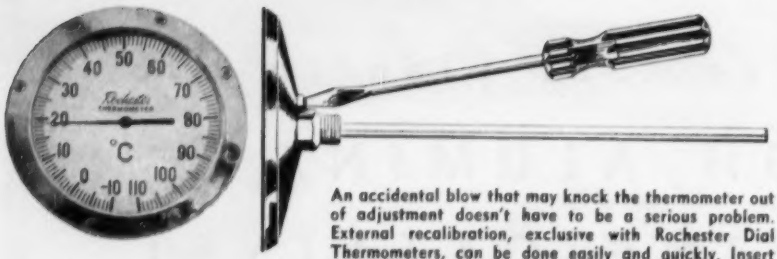

An accidental blow that may knock the thermometer out of adjustment doesn't have to be a serious problem. External recalibration, exclusive with Rochester Dial Thermometers, can be done easily and quickly. Insert the stainless steel stem in any liquid of known temperature and adjust the dial with the set screw attachment. It's done easily and quickly, EXTERNALLY, and is completely accurate.

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Your Rochester representative will be glad to give you additional information, or address your inquiries directly to the Rochester Manufacturing Company, Rochester.

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DIAL THERMOMETERS GAUGES AMMETERS

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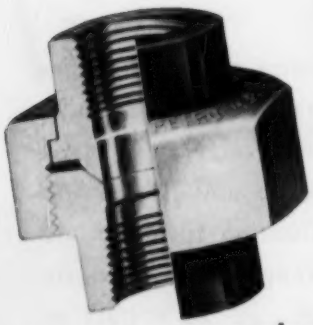

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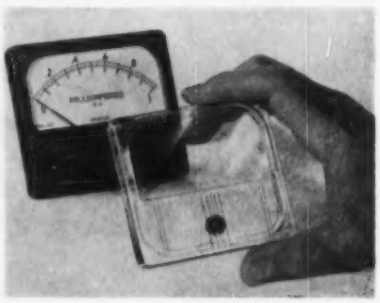
New Equipment . . .

valve body is also intended to provide maximum design flexibility for special applications.

Standard models are listed from 2-inch to 36-inch in ASA Series 150, 300, 400 and 600. The inner trap utilizes a parallel-sided port plate with self-aligning metal seats backed up by an "O" ring seal. The body may be vented or drained to provide positive indication of absolute shutoff. For details on this unit . . .

Circle E11 on Postcard



Electrical Instruments are now available in color with the introduction of Weston Model No. 1331 line of flush rectangular instruments incorporating the Weston Self-Shielded Chromax movement. The instruments, handled by Weston Electrical Instrument Corporation, have a one-piece snap on front with zero corrector and the entire front surface except for the window area can be supplied in any color including black for a quantity built-in requirements. The instrument is the standard 3½-inch Weston type. It is available as DC and Rectifier type AC instruments in popular range. For complete literature and prices . . .

Circle E12 on Postcard

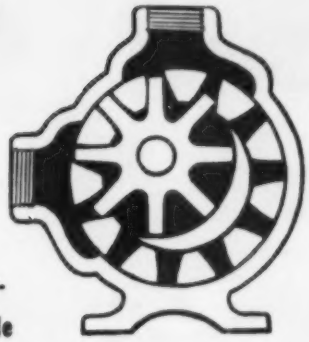
Midget Thermostats, ¼ in. in diameter and less than 2½ in. long, are a new line recently developed by Fenwal, Inc. These new units weigh approximately 1 oz. and are designed for precise temperature control or heat detection applications in heated equipment, bearings, pumps, etc., wherever installation space is at a premium.

The midget Thermoswitch may be set to actuate at any specified temperature between —50 to 500 F. Contacts open when the temperature exceeds this set point. Inverse action models are also available in which the contacts close above set point temperature.

This new midget Thermoswitch is rated to handle an electrical load of 1 amp, at 115 volts A. C. Cartridge bodies and mounting accessories are of polished stainless steel while wiring leads are Teflon (registered PM E. I du Pont de Nemours & Company) coated for long service lift. Complete details are available now . . .

Circle E13 on Postcard

VIKING ROTARY PUMPS



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Professors of Chemical Engineering, Massachusetts Institute of Technology
AND EDWIN R. GILLILAND
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This book concisely and thoroughly presents those principles upon which chemical engineering operations are based, and develops methods for applying these principles to the solution of problems in chemical engineering practice. The opening chapters, which review principles of measurement, laws of fluids, heat, etc., are followed by extensive material on the operations of chemical engineering, including descriptions of processes and equipment and full treatment of problems and methods of design. Special attention is given to illustrative problems and solutions that give helpful suggestions relative to the plan of an experimental run, the data to choose, and the method of solution and interpretation to adopt.

Throughout this revised edition, emphasis is laid on the importance of material and energy balances, equilibria, and rate relationships, and the technique of using these in solving practical problems. Widespread advances in chemical engineering are fully covered in much new or thoroughly rewritten material.

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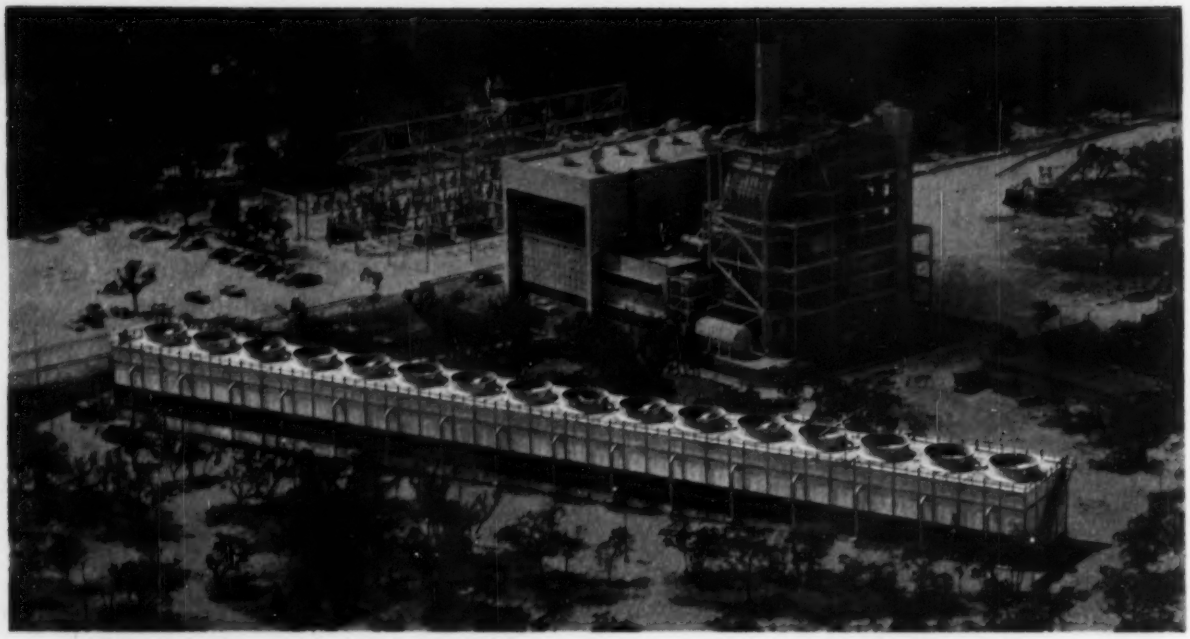
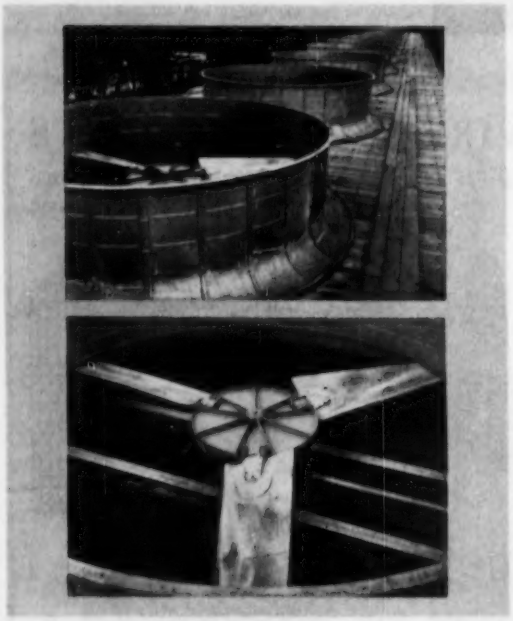


37 Hartzell 18′ Cooling Tower Fans help insure uninterrupted power production at San Antonio's W. B. Tuttle and Leon Creek power plants



Hartzell cooling tower fans play an important role in helping the City Public Service Board meet the growing power demands of the San Antonio area. Hartzite plastic fans are used exclusively on the 16 cell tower at the new W. B. Tuttle power plant and on two towers at the Leon Creek plant.

Continuous, low maintenance fan operation to insure uninterrupted cooling tower service is vital to refinery operations, too. That's why trouble-free Hartzell fans are the choice of the petroleum industry. That's why, where one Hartzite plastic fan has been installed on a tower, "Hartzell" is almost invariably specified as additional fans need replacement.

To get the complete story on how Hartzell fans can help you get better service from your cooling towers and heat exchangers, call your nearby Hartzell field engineer or drop us a line. Do it today. And be sure to ask for your free copy of Bulletin A-112.

The Hartzell cooling tower installations at San Antonio's City Public Service Board power plants were handled by the Hartzell field office at 5717 Kirby Drive, Houston, Texas; phone Jackson 3-4565.

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What's New in Manufacturers' Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Metal Surface Treatments Manual . . . Texas Alloy Products Company has just published a comprehensive manual outlining the various methods of surface treatment to resist abrasion, corrosion, heat and to restore the piece to size. This publication is a comprehensive technical coverage of the possible approaches and materials which may be used. A complete 13-page alloy application's chart is included.

A specification section covers in complete detail the various general methods of metal treatment and gives complete characteristics information with approximate cost data on each type treatment. This manual is of extreme interest and value to those concerned with maintenance, equipment betterment, corrosion mitigation and run length improvement. Just . . .

Circle E14 on Postcard

Molybdenum Catalysts . . . Climax Molybdenum Company has published a new brochure containing process information on the use of Molybdenum Catalysts in oxidation, hydrogenation, dehydrogenation, isomerization, and cyclization. Also, covered is a summary of typical reactions and conditions in such processing. For your copy . . .

Circle E15 on Postcard

Gradiation Heating . . . Selas Corporation of America has available a new bulletin titled "Gradiation Heating for Petroleum and Chemical Processing." The bulletin covers design and operational characteristics of Selas Radiant Transfer Furnaces with operating data. For your copy of Bulletin S-1043, just . . .

Circle E16 on Postcard

High Temperature Castables . . . "Firecrete and Blazecrete" are covered in an illustrated 12-page booklet just issued by Johns-Manville. It describes the characteristics of these hydraulic-setting refractories for services up to 3000 F. Applications information on the various types of castables is included and as are up to date tables on the properties of the material. For your copy of this booklet on "Firecrete and Blazecrete" . . .

Circle E17 on Postcard

Electronic Receiver Recorder . . . Bailey Meter Company has announced a new type of receiver recorder which may house as many as four plug-in, d-c receivers, or two receivers and two pneumatic controllers. Also it is possible to combine four records from d-c pickups, a-c pickups, or pneumatic transmitters on the same uniformly-graduated, circular chart. The d-c receiver operates on the potentiometric null-balance principle, using an electronic voltage reference in place of the conventional standard cell and battery. Just . . .

Circle E18 on Postcard

Electro-Pneumatic Control . . . Complete information about Leeds & Northrup Company's new Series 60 Current-Adjusting Type Control Unit and its associated converter for electro-pneumatic control is now available in an 8-page folder. This new publication describes how this control system—which includes a Speedomax G or H indicator/recorder—combines the advantages of pneumatic valve operation with the flexibility and fast response of an electrical control system.

Included are photographs and drawings illustrating the complete control system and all pertinent details of both the C.A.T. control unit and the electro-pneumatic converter. For your copy of this information . . .

Circle E19 on Postcard

Gas Chromatography . . . A new 12-page bulletin describes the Kromo-Tog, a new self-contained instrument for the analysis of gases and liquids by gas chromatography. Fully explained is the elution method of analysis for which The Kromo-Tog provides all the basic instrumentation needed by the modern laboratory.

Extreme flexibility is featured for The Kromo-Tog. The new instrument embodies simplicity of design, ease of operation and wide usefulness including many applications for which there is no other practicable method. Typical applications include separation of closely boiling isomers of gas and liquid organic compounds, determination of trace components, rapid routine analysis for a control component, analysis of fractions from organic distillations and analysis of organic acids, alcohols, ketones, aromatics, esters and other organic liquids. For your copy of this information bulletin,

Circle E20 on Postcard

Ferrous Metallurgy Chart . . . A revised edition of the Tempil Basic Guide to Ferrous Metallurgy is now available. This chart provides a handy reference source for the engineer, metallurgist, and skilled worker, and has proved to be an excellent teaching aid in fundamental courses on metallurgy.

The principal characteristics of steels (with carbon content ranging to 0.9 percent are represented across the temperature range to 2900 F. The important working zones, including preheating for welding, stress relieving, normalizing, annealing, and forging are shown. At the right of the chart 24 common metallurgical terms are defined and explained. A diagram symbolizing the change in grain size with temperature appears at the left. For your copy . . .

Circle E21 on Postcard

Plain and Rib-Type Seamless Tubing . . . Eisenwerk Kritzler of West Germany has just published in English, a comprehensively illustrated data book on its plain and rib-type seamless tubing for use in boilers, condensers, heat transfer equipment and the like. For further information, just . . .

Circle E22 on Postcard

Process Refractometer . . . Consolidated Engineering Corporation has just published a bulletin, number 1839, covering Consolidated Phillips type 38-201 Process Refractometer. The bulletin contains comprehensive discussion on this instrument and its potential applications. For your copy . . .

Circle E23 on Postcard

Cellular Insulation . . . Pittsburgh Corning Corporation has released a new 8-page catalog on "Foamglas." The new booklet presents the physical properties of the unique cellular glass insulation; sizes and shapes available; and suggested thicknesses required for temperatures ranging from —50 to 800 F. Condensed recommended specifications and photographs of applications make the booklet a reference for engineers, applicators and insulation contractors. To get your copy of this booklet . . .

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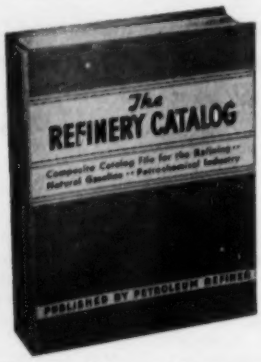

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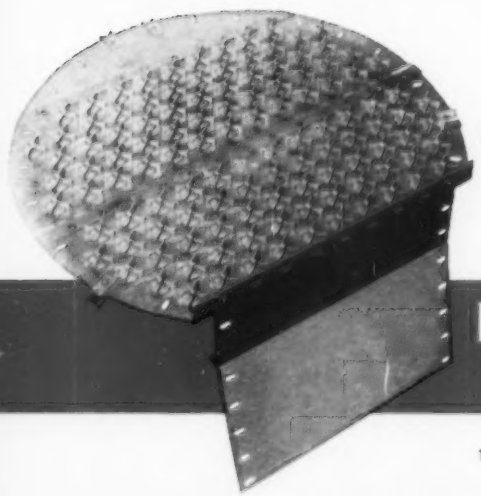

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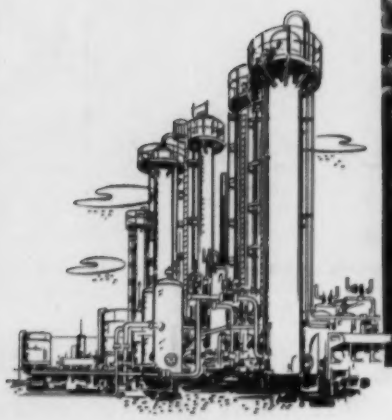

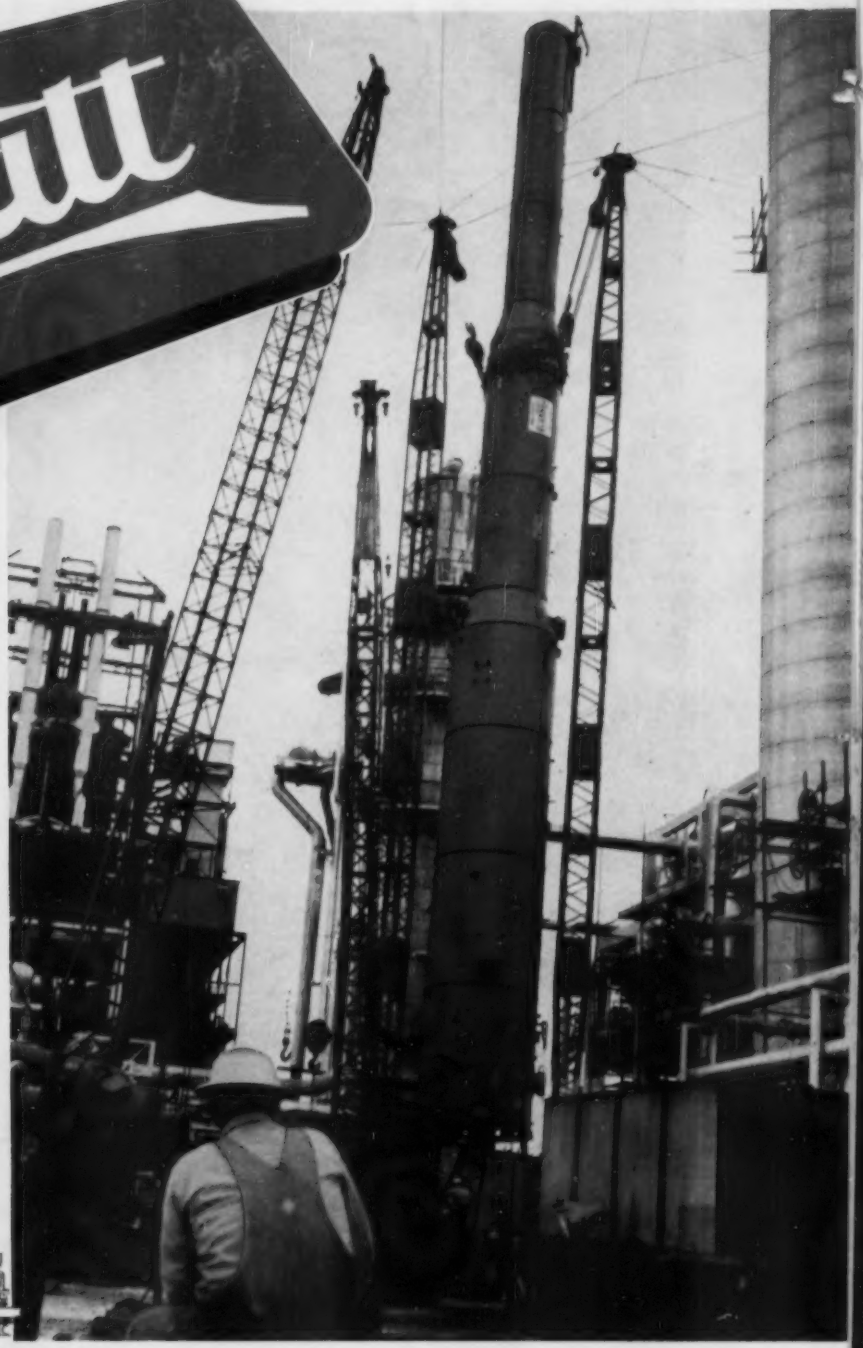

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